Influence of W-type and U-type ventilation methods on working face

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Abstract: To study the influence of U-type ventilation and W-type ventilation on working face and goaf, the monitoring data of gas, carbon monoxide, carbon dioxide, and other gas concentration and air volume in working face 9-204 and 9-211 of Dianping Coal Mine were systematically analyzed. The results show that under the W-type ventilation mode, the air leakage of the working face is small, which will not cause gas accumulation at the upper corner and the end; there is no spontaneous combustion in the gob of these working faces, so the advancing speed of these work face matches the spontaneous combustion period; the oxidation degree of the coal left in the gob with U-type ventilation is slightly higher than that with the W-type ventilation.

1. Introduction
If the coal is prone to spontaneous combustion, the gob can be divided into three zones: heat dissipation zone, spontaneous combustion zone, and suffocation zone. The distribution law of the three zones in the gob is very important for preventing coal seam spontaneous combustion in the goaf. Generally, a reasonable working surface advancement speed and fire extinguishing system can be formulated according to the distribution range of the oxidation zone and spontaneous combustion ignition period, which can effectively prevent the goaf Spontaneous combustion. The distribution characteristics of the three zones in the mined-out area will be affected by factors such as ventilation methods and air leakage. Scholars have done a lot of research on it. Hao yu[1] established the mathematical model of multi-field coupling and got the law of spontaneous combustion of “three zones” in the gob; Cheng Chunlian[2] conducted a numerical simulation study on a mine in Guizhou, obtained the gas migration law before and after the use of W-type ventilation system; Wei Bingsheng[3] conducted a numerical simulation and obtained the result that W-type ventilation can reduce the air leakage and ventilation resistance of the working face. Liu Jiujia[4] studied the spontaneous combustion zone and gas migration law in a goaf of a mine, and conducted numerical simulations, and found that W-type ventilation can solve gas override at the upper corner and reduce the influence range of gas explosion in goaf.

This paper takes the 204 and 211 working faces in 9# coal in the mine as the engineering background. Through actual measurement and theoretical analysis, systematic research is carried out on the air leakage of the working face and the gas concentration (gas, carbon dioxide, oxygen, etc.) at different positions when the W-type and U-type Ventilations are adopted respectively. Through comparative analysis, the effects of different ventilation modes on gas migration and spontaneous combustion in the gob are obtained.
2. Overview of Engineering Geology
The Coal Mine is located in the north of Zhongyang-Lishi syncline. Its shaft runs through the entire mine field and the gas concentration is relatively high in the shaft. The 204 and 211 working faces are both located in the second mining area in the 830 level. The coal seams average thickness of the is 2.5 m, and the dip angle is 1-6°, it is the near horizontal. The recoverable coal seam above 9# coal seam is 5# (not mined), and the distance is 55-64 m between 5# and 9# coal seam. 9# coal floor is sandy mudstone, with a layer of coal line (average thickness is 0.5-0.6 m) 6-7 m below. (long-wall comprehensive mechanized coal mining method). The 204 working face is located in the left flank, and it belongs to the second mining area, the east is the boundary of the mine field, the west is 830 large lanes, the south is solid coal, the north is adjacent to the 202 working face (recovered), the seam elevation is + 835m to + 850m; Working face ventilation is W-type (as shown in Figure 1).

3. U-type and W-type ventilation on the influence of various CH₄ concentrations
3.1 CH₄ concentration of different ventilation methods
Based on the monitoring data, the CH₄ concentration in the upper corners, face ends, work faces, and return airflow of the 204 and 211 working faces is obtained (Figure 3). During production, the CH₄...
concentration at the 211 mining face is up to 0.28%, the upper corner is 0.7%, the highest in the return airflow is 0.32%, and the CH₄ emission from the work face is 4.94 m³/min. The maximum CH₄ concentration in the 204 working face is 0.14%, the maximum gas concentration in the scraper conveyor tail is 0.12%, the maximum CH₄ concentration is 0.14% in the return airflow, and the gas emission from the work face is 1.89 m³/min. 211 face is located in the gas-rich area of the syncline axis, so the gas emission is significantly higher than 204 face.

It can be seen from Figure 3 that the U-shaped ventilation method (211 working face) has a large difference in CH₄ concentration at the upper corner, working face and return airflow, especially at the upper corner. It shows that the U-shaped ventilation is easy to cause gas accumulation in the upper corner. The end of the W ventilation mode (204 working face), the working surface, and the return airflow concentration are similar, indicating that the gas release at each position of the W ventilation mode is relatively uniform. This type of ventilation mode will not cause the accumulation of CH₄ in the face, and avoid the corner gas overrun.

![Figure 3. Gas concentration at different locations of two working face](image)

### 3.2 Comparison of gas concentration in corresponding positions of two ventilation methods

To determine the difference in gas composition at different locations (gob, working face, and return airflow), when adopting different ventilation methods. Through continuous monitoring of each point, gas samples at each measurement point are collected, various gas concentrations are obtained by analyzing the composition of the gas. At present, the most frequently used at present is the "beam tube" sampling analysis method, and the method is simple and reliable. This article mainly counts the gases related to the heat dissipation and spontaneous combustion state of the goaf (CO, O₂, CO₂). The beam tube of the 211 goaf is about 50 m away from the working surface, and the beam tube position of the 204 remaining lane section is also about 50m from the working surface. The other beam tubes are newly buried beam tubes at this location.

#### 3.2.1 Comparison of CO concentration between two working faces.

Through the analysis of the CO concentration using the above two ventilation methods, it is found that whether it is U-shaped or W-shaped ventilation, the CO concentration is all Zero at the goaf, upper corner, end, and other positions 50 m away from the working surface. It shows that the spoiled coal in the mined-out area has no spontaneous combustion under the two ventilation methods. The reason is that the thickness of No. 9 coal in the Coal Mine is 2.5 m. It adopts full mining height at one time, so there is less coal left in the goaf and the advancing speed of working face is fast. It shows that the advancing speed is satisfied with the spontaneous combustion period.

#### 3.2.2 Comparison of O₂ concentration between two working faces.

At present, the most frequently used method for dividing the three zones is divided by O₂ concentration in the mined-out area. The area with an oxygen content exceeds 18% is a heat dissipation zone, the area less than 10% is a suffocation zone, Oxygen concentration between 10% and 18% is the oxidation zone. The oxygen concentration in the two ventilation modes is shown in Figure 4. The upper corner of the 211 working face, the return airflow and the end, the return airflow of the 204 working face of the O₂ concentration of are all above 20%; the O₂ concentration of 50m within the goaf of the 211 working face and 204 working face is about
9% (The highest is 9.44%), it shows that those sites are in the oxidation zone.

![Figure 4. O2 concentration at various locations of two working face](image)

![Figure 5. CO2 concentration at various locations of two working face](image)

3.2.3 Comparison of CO2 concentration between two working faces. The CO2 concentration in the goaf, upper corner and return airflow of the 211 face is higher than that of the 204 face (Figure 5). This shows that the slow oxidation effect of each position is higher when U-type ventilation is adopted.

The highest CO2 concentration in goaf (50 m away from working face) of the working face is 0.053%. The highest level of retained entry in the work face is 0.037%. The maximum CO2 concentration at the lower end of 204 working face is 0.037%, and the maximum upper corner of 211 working face is 0.045%. It can be seen that the U-type ventilation method is more likely to lead to the coal seam to slowly oxidize.

3.3 The influence of two ventilation methods on the air leakage of working face

The air velocity and air volume of the air inlet of the coal mining face not only affect the volume of the air leakage in the goaf but also directly affect the scope of the oxidation zone. The greater the inlet air speed and the supply air volume, the larger the area of the oxidation zone.\cite{7,8} There is one air inlet and return air lanes on the working face with U-shaped ventilation, and two air inlet and one return air lane on the face with W-type ventilation. In this paper, the wind speed of the air inlet of 204 face is 1.46 m/s, the average air supply is 1350 m³/min, and the wind speed of the inlet air of 211 face is 1.82 m/s, and the average air supply is 1673 m³/min (Figure 6). Therefore, under the U-shaped ventilation method, the area and width of the oxidation zone in the goaf are higher than those of the W-shaped ventilation method.
The air supply volume is different, and the layout of the roadway is different under different ventilation methods. The number of intake and return roadways are different. Therefore, the amount of air leakage in the goaf is also different. The average air leakage of 211 working face is 225 m³/min, and the average air leakage volume of 204 working face is 116 m³/min (Figure 6). Since the 211 working face is in the gas-rich area of the syncline axis, its air supply is higher than the 204 working face (air volume ratio is 1.24), but its air leakage is significantly higher than the 204 working face, and the air leakage ratio is 1.94. It means that the working has significantly higher air leakage when the U-type ventilation method is adopted. The degree of air leakage is significantly higher than that of W-type ventilation. Air leakage from the working face has an important effect on the distribution of the three belts: air leakage will not only provide sufficient oxygen to the coal in the goaf and promote oxidation, in addition to the wind can also take away the heat generated by the oxidation and reduce the temperature of the goaf. The range of the heat dissipation zone penetrates deep into the mined-out area, resulting in changes in the distribution characteristics of the three zones in the mined-out area.

4. Conclusion
There are different cross-sections and layouts of the roadway in 204 and 211 working face. There is a significant difference between the CH₄ accumulation at the end of the working face, the degree of air leakage in the goaf, and the gas concentration.

(1) In U-type ventilation, the wind pressure on the working face is gradually reduced along the air path, resulting in high air leakage intensity, so the effective air volume on the working face is small. Gas accumulation at the upper corner of the goaf will easily cause the upper corner gas to exceed the limit; W-shaped ventilation has 2 air inlet roadway, the air pressure at the intersection of the intake air is similar, the air leakage at the working face is relatively small, the effective air volume is high, and the working face no longer has gas accumulation corners.

(2) The average thickness of 9º coal seam in the Coal Mine is 2.5m, and the spontaneous combustion period is 80 days (category II spontaneous combustion). Due to little coal left in the goaf, the monitoring data shows that the carbon monoxide concentration at each position of the two working faces is zero, so no coal seam spontaneous combustion occurs in the oxidation zone of the goaf.

(3) The oxygen concentration of 211 working face and 204 working faces about 50m away from the working face is about 9%. Regardless of the U-type or W-Type ventilation method, this location is within the oxidation zone; the CO₂ concentration in 211 goaf is higher than that in 204 goaf, indicating that the U-type ventilation method has a slightly higher oxidation degree than the W-type ventilation method.

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