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Regular pattern effect of negative pressure on spontaneous combustion in gob

To Kailuan Group Lv Jiatuo mine 5877Y working face gob as the research background, and using the method of numerical simulation and field experiment, the effect of different drainage pressure on spontaneous combustion "three zones" under the condition of the buried pipe in the gob was studied. Results show that after the negative pressure is added, the spontaneous combustion zone width of the gob is smaller and then increases. Based on the analysis of the data obtained from field beam tube, the simulation results agree well with the simulation results, which proves the validity of the simulation of spontaneous combustion in gob, and provides a reasonable reference for the gas drainage in the similar condition. Fire and gas are the two major disasters that restrict the safety and efficient development of coal mine, spontaneous combustion in gob is the current coal enterprises especially the great disaster of coal seam spontaneous combustion tendency exists. At present, many mines adopt gas drainage method with high suction roadway to control gas overrun, this method also has great influence on the air leakage field in gob, increase the probability of spontaneous combustion of residual coal. Therefore, it is of important and practical significance to prevent spontaneous combustion of abandoned coal in gob and avoid fire accidents under pumping condition. Based on the study of the mechanism of spontaneous combustion of coal, the theory of gas drainage and the theory of three zones of spontaneous combustion, the application and research status at home and abroad are summarized. To Kailuan Group Lv Jiatuo mine 5877Y working face gob as the research background, and using the method of numerical simulation and field experiment, the effect of different drainage pressure on spontaneous combustion "three zones" under the condition of the buried pipe in the gob was studied. Results show that the distribution of oxygen concentration field under the condition of no buried gas drainage was simulated by establishing the mathematical model of spontaneous combustion in gob and using COMSOL numerical simulation software. The rationality of the model is confirmed by comparing the experimental data and the simulation analysis of the beam tube monitoring, Then, under the condition that other conditions and parameters remain unchanged, the negative pressure of buried pipes with 10kPa, 20kPa and 30kPa sizes is set. The range and influence law of "three zones" of spontaneous combustion in gob under different pumping negative pressure are obtained; When the negative pressure is added to the gob, the width of the spontaneous combustion zone in the gob becomes smaller and then increases. The data obtained from the monitoring of the beam tube on the spot coincide with the results of the simulation. The validity of the spontaneous combustion simulation in the gob is well verified, The research results provide theoretical support and basis for mastering the heating law of spontaneous combustion of abandoned coal in the gob and preventing and controlling the spontaneous combustion of coal seam.

Keywords: *Numerical simulation, field experiment, negative pressure, spontaneous combustion.*

1. Introduction

In recent years, most coal mining enterprises have been equipped with gas drainage system for the control of gas, and the gas concentration in gob is reduced by means of intubation, buried pipe method or drilling method[1-2]. How to effectively and effectively control gas and prevent the occurrence of some secondary disasters such as coal spontaneous combustion during gas drainage has become a hot research topic in recent years. But at the same time, the negative pressure conditions are provided by the gas drainage and increases the mined-out area of leakage air volume. It increases the oxygen concentration, leads to air in gob seepage which is very complex; coal spontaneous combustion in the gob provides favourable conditions [3].

Spontaneous combustion in gob is the current coal enterprises especially the great disaster of coal seam spontaneous combustion tendency exists[4], the research of gob spontaneous combustion rule is very important for the safety of coal mining. Therefore, how to effectively control gas safety, gas drainage and prevent the process of spontaneous combustion of residual coal and some other

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secondary disasters[5], become the research hotspot in recent years. However, coal mine gob spontaneous combustion is an extremely complex which covers the physical and chemical change of heat transfer and mass transfer process, at the same time around the formation of the coal mine gob spontaneous combustion process are affected by heat source heating and the heat environment of mutual influence [6].

So research drainage negative pressure condition by adopting the method of numerical simulation of gob spontaneous combustion rule and the influence of "three zones" distribution, to achieve safe and efficient mining of coal mining enterprises has important practical significance.

2. Project profile

The 5877Y working face of Lv Jiatuo coal mine is located at -800 m eight mining area, and the 7 coal seam roof aquifer is the direct water filling aquifer of the face. The parameters of working face to a length of 270 meters, recoverable length is 200 m; the working surface inclined length is 100 m, the average angle is 19°; seam is 7 coal seam, the average thickness is 3.73m, the structure of coal seam is composite structure; air coal mining face is 803.2 m^3/min, air volume 615 m^3/min; two carbon dioxide emission relating to the amount is 1.85 m^3/t, the relative gas emission rate is 1.23 m^3/t, with mining, increase the quantity of gas emission in working face, in order to effectively solve the upper corner gas accumulation, the gas drainage pipe is burying method.

Based on the mechanism of spontaneous combustion in gob, in Lv Jiatuo mine of Kailuan Group 5877Y surface as the object of study, in consideration of various factors of air leakage and oxygen exothermic rate of gob seepage, coal oxidation temperature and oxygen consumption effect, combined with the COMSOL-multiphysics 5.1 version which is the more physical fields numerical simulation software, we simulate the buried tube drainage differently before and after the drainage of gob spontaneous combustion "three zones" under the condition of negative pressure range, for mine reasonable drainage parameters, prevention and governance gob spontaneous combustion provides effective theoretical basis.

3. Numerical simulation of spontaneous combustion in gob

The accumulation of heat generated by the exothermic oxidation of coal is the main cause of the spontaneous combustion of residual coal in gob[7]. In order to study the process of spontaneous combustion of abandoned coal in gob, experts and scholars have established many related mathematical models. The process of coal spontaneous combustion in the general sense refers to the heat, flow and chemical reaction process, the usually gob of coal rock is studied as a porous medium, and the mined out area gas has extremely strong non Darcy flow characteristics[8]. Therefore, the percolation state of the transition region is described by using non Western processes. Based on the conservation of energy, conservation of momentum and continuity equation, we built a multi physics field mathematical model of spontaneous combustion in gob, and solved numerically by COMSOL software, through the establishment of physical model, grid, set parameters, solver to solve the related physical variables that mining distribution of gob "three zones". In the condition of air leakage, coal thickness, porosity, thermal conductivity and other parameters under the same conditions, simply change the drainage parameters, by comparing and analyzing the simulation results, the influence law of different suction negative pressure on spontaneous combustion and "three zones" range is obtained.

After COMSOL numerical simulation, the oxygen concentration field distribution in the gob can be obtained. The oxygen concentration in the solution used in the process is the amount of substance concentration, inlet is about 9.5 mol/m^3, for convenience of observation, the oxygen concentration is converted to volume fraction (%) when graphical output is displayed. As can be seen from Fig.1, the air inlet oxygen ratio is 21.2%. With the oxygen diffusion and the oxygen consumption of the residual coal oxidation reaction, the oxygen concentration gradually decreases along the gob depth, and after 60 m, the oxygen concentration tends to 0. In the area of 30m from the work face, although there is the oxygen consumption of the residual coal, the air leakage in this area is large, the porosity is large, and the air flow rate is large, thus providing sufficient oxygen, so that the oxygen concentration can be maintained at a high level. By flow, diffusion and consumption process, the air intake section of inflow of high concentration oxygen arrive the gob air side oxygen concentration, and at the same time the concentration oxygen has been greatly reduced, and after the oxidation of the residual coal with the return air, the oxygen concentration drops to a lower level, and then flow out of the mined out area with the airflow.

According to the analysis of Fig.1, under the condition of no buried pipe drainage, the three zones of spontaneous

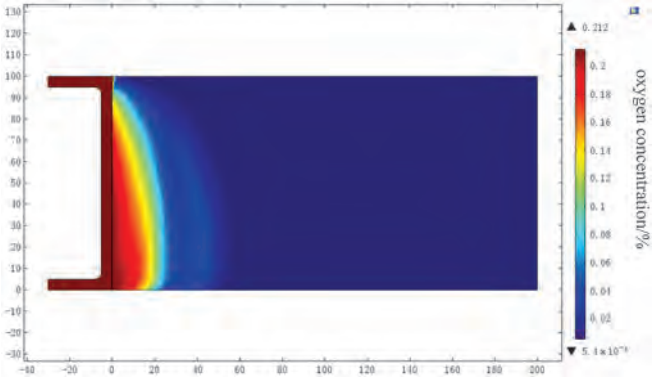

Fig.1 Oxygen concentration distribution in gob when no buried pipe is taken out

combustion in gob are unevenly distributed, and three spontaneous combustion zones are divided according to oxygen concentration, The oxygen concentration of the cooling band is greater than 18%, the range of oxygen concentration in the spontaneous combustion zone is 8%-18%, and the oxygen concentration in the suffocation zone is less than 8%[9]. The air inlet side spontaneous combustion zone is 15 m away from the working face, the width is 30 m, while the upper corner gas concentration of the return air side is larger, and the oxygen concentration is smaller. The width of the spontaneous combustion zone is gradually decreasing from the direction of the inlet side to the return air side.

When in the upper corner of the gob is arranged at the buried pipe, according to the construction plan of drainage pipe into the gob at 25 m, on the basis of the parameters were simulated in COMSOL. Through simulation analysis, when the suction pressure is set at 10 kPa, The spontaneous combustion zone is 15 m from the coal wall at the working face, with a width of 35 m, compared to the drainage before spontaneous combustion zone distance unchanged, width increased by 5 m; when the suction pressure is set at 20 kPa, the spontaneous combustion zone is 25 m from the working surface, and the width is 50m, compared to the drainage before distance back 5 m, width 5 m; when the suction pressure is set at 30 kPa, The spontaneous combustion zone is 25 m from the working surface, and the width is 50m, a drainage before distance back 10 m, increasing the width of 20 m. Fig.2 shows the oxygen concentration profiles obtained from the gas extraction by simulating the suction pressure of 20 kPa. As can be seen from Fig.2, due to the leakage of air pressure and suction negative pressure to form convection, from the air side to the return air side of spontaneous combustion, the three zones distribution is more uniform. By the numerical simulation, it is concluded that when the suction negative pressure is 20 kPa, the width of the spontaneous combustion zone is minimum, which is most beneficial to prevent the spontaneous combustion of residual coal caused by the leakage of air.

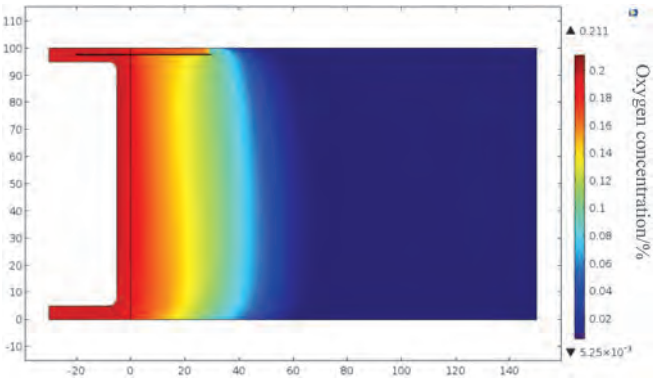

Fig.2 Oxygen concentration distribution in gob under pumping negative pressure of 20kPa

4. Field test analysis

By using field beam tube monitoring technique, monitor the effect of oxygen concentration distribution when the suction pressure of the buried pipe is 20kPa. The arrangement of the beam tube adopts the method of distributing line along the inclined plane of the working face, four measuring points are arranged behind the hydraulic support, the 1# monitoring point is arranged in the upper corner position, the 2# and 3# monitoring points are arranged in the middle position of tilt direction of working face, interval 30m, the 4# monitoring points are arranged in the lower corner position. A beam tube is laid at each monitoring point from the beam pipe monitoring station, and the bundle tube is placed in the steel casing so as to ensure that the beam tube is not damaged during the monitoring process[10] .

When carry on the scene detection, through the vacuum pump will arrange underground gas samples collected from the sampling points are filled with 4 different ball, and mark them, sent to the laboratory for laboratory analysis. The GC4085 gas chromatograph was used in the test and analysis. O_2, CO, CO_2 and C_2H_4, C_2H_6 and other gases were analyzed emphatically. The sampling time was once daily, and the records were recorded in real time.

According to the oxygen concentration, the “three zones” of spontaneous combustion in gob are divided. The area where the oxygen concentration in the gob is less than 8% is generally located in the deep part of the gob with lower oxygen concentration; it is insufficient to think that the loose coal body provides sufficient oxygen for the oxidation reaction. In theory, there is no possibility of spontaneous combustion. This area is defined as the suffocation zone; the area where oxygen concentration is greater than 18% is generally located in the shallow part of the gob and away from the coal wall near the working face where the oxygen is plentiful. But the intensity of air leakage is also large, and the heat released by the oxidation reaction of loose coal is carried out by the airflow, and the heat cannot accumulate and rise. In theory, spontaneous combustion is not possible, so the area is defined as a loose zone. The oxygen concentration is between 8%~18% and the zone whereas between the cooling band and the choke belt. The oxygen concentration is enough to provide exothermic heat to the loose coal body, but the air leak intensity is small and only a small amount of heat can be taken away. The accumulation of heat and the rise of temperature are likely to cause the spontaneous combustion of the residual coal in the gob, so the area is defined as the spontaneous combustion zone. According to the volume concentration of O_2 in the gas sample taken, the line diagram of the oxygen concentration distribution in the mined out area as shown in Fig.3 is drawn.

From the analysis of Fig.3, it can be seen that the oxygen concentration distribution in the mined area monitored by field test is basically consistent with the numerical simulation.

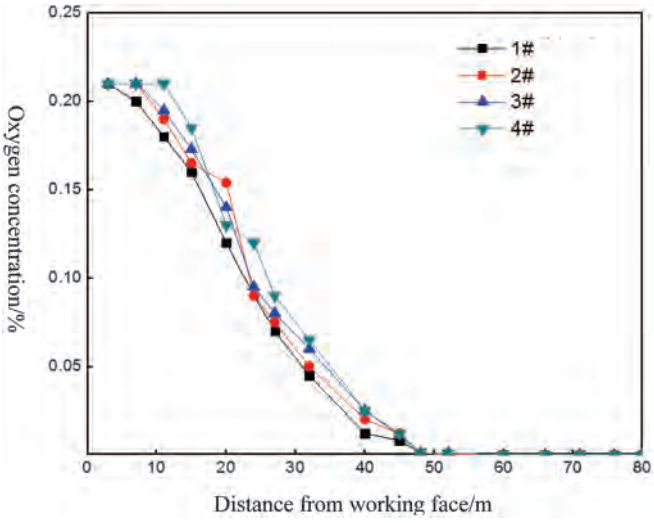

Fig.3 Monitoring and analysis diagram of oxygen concentration in mined out area

Based on the simulation results above on, the 5877y working face of Lv Jiatuo coal mine in Kailuan Group mainly adopts the gas immersed pipe to control the gas, and the negative pressure is 20 kPa. During the actual mining period, there was no shutdown due to excessive gas and CO, The gas and coal spontaneous combustion in the working face are all within the safe controllable range, and the safe, efficient and continuous mining is realized.

5. Conclusions

The numerical simulation results show that the width of spontaneous combustion zone in gob varies with negative pressure when adding negative pressure to suction gas. When setting suction negative pressure is 20 kPa, the effect is best, at this time, the width of spontaneous combustion zone is 25m.

By establishing the mathematical model of spontaneous combustion in gob and using COMSOL numerical simulation software, the distribution of oxygen concentration field under the condition of no buried gas drainage was simulated . The rationality of the model is confirmed by comparing the experimental data and the simulation analysis of the beam tube monitoring, Then, under the condition that other conditions and parameters remain unchanged, the negative pressure of buried pipes with 10kPa, 20kPa and 30kPa sizes is set. It is better to verify the influence of negative drainage on spontaneous combustion and "three zones" division in gob under the condition of buried pipe drainage. The research results provide theoretical support and basis for mastering the heating law of spontaneous combustion of abandoned coal in the gob and preventing and controlling the spontaneous combustion of coal seam. It has important practical significance for preventing the spontaneous combustion of coal in the gob and reducing the occurrence of similar coal mine safety accidents.

Acknowledgements

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