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STUDY ON INDICATOR GAS OF SPONTANEOUS COMBUSTION AND PREVENTION MEASURES

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Abstract: Coal spontaneous combustion is one of the main causes of mine fire, in order to more targeted prevention and control coal seam spontaneous combustion, the Sun Jiagou $13^{\#}$ coal samples of the gas samples of the experimental study, the results show that the gas is CO, H_2, C_2H_2 and C_2H_4. The state and development trend of the spontaneous combustion of the coal seam are further judged by the law of the change of the index gas with the temperature, and the experimental basis is provided for the prediction of spontaneous combustion of the coal seam in the $13^{\#}$ coal seam of Sunjiagou. The experimental study shows that when the coal seam is found in the underground gas, the coal seam has the potential danger of spontaneous combustion of coal seam, and it can judge the oxidation stage of coal at this time. The grouting method can be used to control coal spontaneous combustion quickly and effectively.
Keywords: Spontaneous combustion of coal seam; index gas; alkane gas; grouting method.

1. Introduction

Spontaneous combustion of coal is a complicated physical and chemical process, and it is also an important aspect of mine fire control management. Coal spontaneous combustion is a self accelerating exothermic oxidation, oxygen molecules to form physical and chemical adsorption heat on the surface of coal, coal to slowly rising temperature and depth of oxidation and decomposition heat of coal surface molecules, releasing large amounts of heat of reaction, the heat in the body of the coal accumulation resulting in coal spontaneous combustion [1-2]. Gases released from coal during low temperature oxidation can be used as indicator gases to determine the spontaneous combustion state of coal [3]. The accurate determination of the concentration and the critical value of the index gas can be used to identify the development stages and severity of spontaneous combustion and spontaneous combustion of coal, which plays an important role in the early prevention and control of coal

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spontaneous combustion [4]. Grouting method [5] is to use the pipeline to send the slurry to the place that may or has occurred spontaneous combustion, so as to prevent spontaneous combustion or put out the fire, which is a common method used in coal mine fire prevention and extinguishing.

2 General situation of coal seam

The maximum thickness of $13^{\#}$ coal seam is 15.45 m, minimum 7.35 m, average 13.05 m. The west of the exploration area has bifurcation phenomenon, and the coal thickness in the western exploration area has obvious thinning trend. Coal seam structure is complex, including stone 1 to 4 layers, folder stone thickness 0.20 ~ 0.75 m, But most of them are between 0.30~0.50 m, only the local section is more than 0.50 m, the lithology is mudstone or carbonaceous mudstone, and the roof and floor are mudstone or sandy mudstone. Coal seam recoverable index Km=1, Variation coefficient of coal thickness γ=20.21%, It belongs to the special thick coal seam which is stable and recoverable in the whole area. The coal seam has the tendency of spontaneous combustion, and the gas content is low. Ash content is 17.57%, sulfur content is 1.13%, and coal volatile is 33.62%.

3 Experiment

$13^{\#}$ coal seam was collected according to GB482-1995 "coal seam sampling method", and was sent to the mine fire laboratory in China and australia. The experiment instrument uses the self-developed coal spontaneous combustion characteristic comprehensive test system to carry on the coal sample test. Coal samples were collected after the sealed package shipped to the laboratory, experimental sampling before removal of oxidized coal surface layer, the crushing and screening the size of 40~80 particles to 50 g as experimental coal sample using coal crusher. The 50 g size for 40~80 coal into coal to copper pot, then the coal tank into the program temperature control box, and then connect the air inlet, an air outlet pipeline and a temperature probe (probe in the geometric center of the coal tank), check the air tightness test management way. The test to the coal sample through 80 cm3/min dry air, while the coal sample (The temperature gradient is 1 /min), from 30 ^{O}C to 220 ^{O}C, during every 10^{O}C take gas sample analysis of gas composition and concentration [6-8].

4 Variation law and analysis of gas sample

Through the experimental monitoring, we obtained the change rule and the amount of the gas product of coal sample with the coal temperature, and the law is shown in figure 1~4.

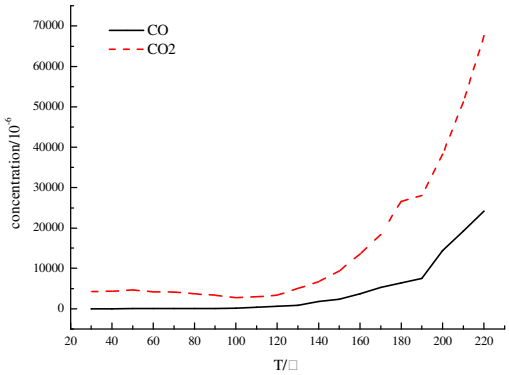

Fig. 1 concentration variation of CO and CO_2 heating process of coal sample concentration

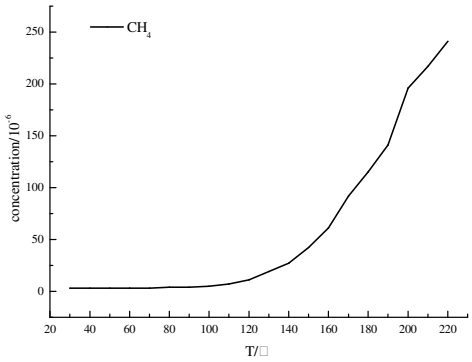

Fig. 2 Variation Law of CH4 during during coal sample warming process

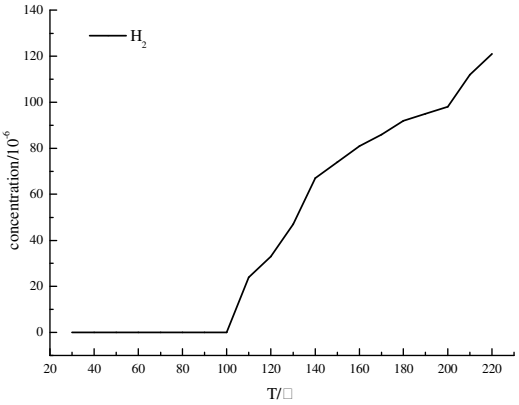

Fig. 3 Variation Law of H_2 concentration during coal sample warming process

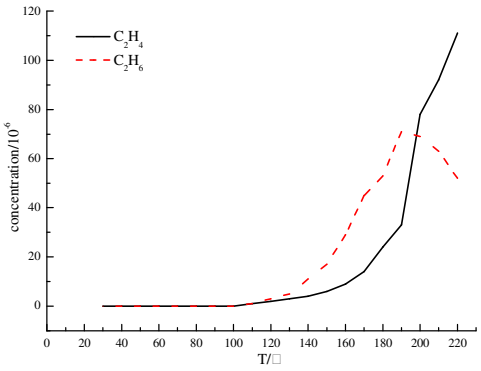

Fig. 4 concentration variation of C_2H_4 and C_2H_6 during heating process of coal sample

4.1 The law of CO and CO_2 gas generation

It can be seen from the figure 1 that CO began to appear at the initial temperature of 30 ^{O}C, which is the earliest oxidation gas product in the process of coal oxidation, and runs through the whole process of temperature rising and oxidation. Before 220 ^{O}C of temperature, the yield of coal is in an exponential relationship with the coal temperature, and is divided into two stages: Before 80 ^{O}C, the CO increases slightly with the increase of coal temperature; At 80 ~220 ^{O}C, the slope of the curve is large, and the CO increases rapidly with the increase of the coal temperature, which indicates that the coal has begun to oxidize rapidly. Therefore, carbon monoxide can be used as an indicator gas of the coal seam, but because of its large

range of production, it needs to be combined with other gases to analyze and predict coal spontaneous combustion more accurately. The heating CO_2 gas in the process of coal oxidation production with coal temperature increased firstly and then decreased from Figure 1 can generate CO_2, that is not all by oxidation, may be desorbed from coal, CO_2 gas production rules should not be summed up, so in the use of index gases do not take CO_2 gas.

4.2 Gas generation law of alkanes and alkenes

It can be seen from Figure 2 that the experimental coal samples begin to appear at 30 ^{O}C centigrade in the test temperature range, and the concentration increases gradually with the increase of temperature in CH_4. It is shown that native CH_4 exists, and the amount of its formation increases with the increase of temperature. The methane content in the mine is affected by mining and coal falling, so the methane is not suitable for the index gas of the coal seam.

It can be seen from the figure 3 that the formation of H_2 has the following characteristics in the process of coal temperature rising oxidation experiment:H_2 could not be detected before 110 ^{O}C, H_2 began to appear after 110 ^{O}C; with the appearance of H_2, the content increased sharply with the increase of coal temperature. The detection of H_2 indicates that the coal enters the accelerated oxidation stage. Therefore, H_2 can be used as indicator gas in the coal seam.

In view of Figure 4, the relationship between C_2H_4 production rate and coal temperature is relatively clear, C_2H_4 began to appear at 110 ^{O}C, and its concentration increased slowly with the increase of coal temperature; The concentration of C_2H_4 increased rapidly with the increase of coal temperature at 180 ^{O}C, and showed an exponential growth trend; The occurrence of C_2H_4 indicates that coal has entered the stage of oxidation releasing gas, and immediate measures should be taken. Because of the difference between the experimental conditions and the actual conditions, the relationship between the C_2H_4 production and the coal temperature is not clear, but the critical temperature has great application value. Once the C_2H_4 gas is detected at the site, it is indicated that the coal temperature has exceeded its critical temperature at this time, and immediate measures should be taken.

C_2H_6 began to appear at 100~110 ^{O}C, but its production increased first and then

decreased with the increase of temperature, which indicated that a considerable amount of C_2H_6 was produced by desorption of coal. It is not suitable to be used as index gas in this coal seam.

C_2H_2 gas is the product of coal oxidation into combustion stage, which is the latest gas in all the products of spontaneous oxidation gas, and the critical temperature is higher. So C_2H_2 gas is an important index gas of coal spontaneous combustion. From the experimental results, no C_2H_2 gas was detected in the process of coal oxidation heating, indicating that the temperature was higher than 220 ^{O}C. Once found in the pit of C_2H_2 gas show in the monitoring area there is fire has entered the burning stage, take measures at this time must be careful to avoid direct fire will be exposed to the air, to prevent gas and coal dust explosion triggered.

5 Fire prevention scheme of 13# seam grouting method

5.1 Grouting scheme and material selection

In order to ensure the timely and simple treatment of spontaneous combustion hidden danger, according to the 13# coal seam spontaneous combustion mark gas, combined with the mining characteristics of the coal seam, the method of grouting with pipe grouting is adopted. The surface soil is mostly loess and the material is convenient, so the loess is chosen as the grouting material. Grouting pipe laying is: Ground Grouting station→New return air inclined shaft→Main return air lane→West mountain south wind Lane Lane→13306 working face intake→Mined out area, The total length of the line is about 4000 m.

5.2 Grouting design

5.2.1 Surface layout of yellow mud

The ground arrangement of the fixed grouting fire prevention system diagram is shown in Figure 5, according to the actual situation, combined with the coal mine grouting fire extinguishing technical specifications, After calculation, the ratio of grouting slurry is 1:3, the required soil quantity is 210 t/d, the water consumption is 462 t/d, and the grouting quantity is 516 m^3/d.

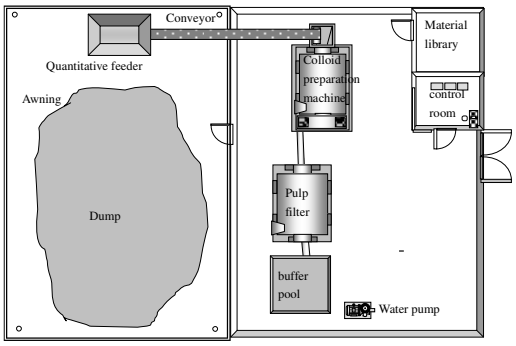

Fig. 5 plane layout of ground fixed grouting fire prevention and extinguishing system

5.2.2 Grouting system process flow

Before the first caving, along the wind Lane in the goaf laid out in advance 10~20m embedded grouting pipe pre buried grouting pipe end through the goaf, the other end is connected with a length of 20~30m high pressure hose, filling pipe and hose connection, every day will use grouting pipe winch pull, pull the distance to work on the advancing distance of embedded pipe, which remains in the goaf around 15m, so as to avoid the effects of filling mining. Yellow mud accumulation occurs at the corner above grouting. Fig. 6 is a grouting plan for buried pipe.

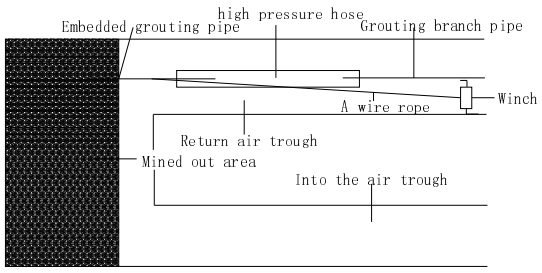

Fig. 6 grouting schematic diagram of buried pipe

6 Conclusion

1) Through the experiment research on the index gas of 13# coal seam, the index gas suitable for the coal seam is CO, H_2, C_2H_2, C_2H_4. There is a close relationship between gas and coal temperature in the process of spontaneous combustion of coal. In the process of ignition prediction, we should take into account the various indicators, mainly CO, and H_2, C_2H_2, C_2H_4 and other auxiliary gases to master the coal spontaneous combustion situation.

2) The coal seam of 13# test, CO concentration the higher the coal spontaneous combustion risk is higher, H_2 and C_2H_4 show that the coal gas release has entered the

oxidation stage, the coal temperature should be 110 ^{O}C, it is accelerated oxidation stage of coal spontaneous combustion process, should take immediate measures. The C_2H_2 gas has not appeared in the temperature range of this experiment, indicating that the temperature is higher than 220 ^{O}C, and a large number of studies show that C_2H_2 is the symbol of the oxidation of coal into the stage of intense oxidation combustion. So once C_2H_2, it shows that coal has undergone violent chemical reactions.

3) 13$^{\#}$ seam adopts grouting method to prevent spontaneous combustion of coal seam. By analyzing the gas sample collected by bundle tube, combining with the index gas of spontaneous combustion of coal, and forecasting the actual situation of monitoring point in time, it is beneficial to prevent spontaneous combustion of 13$^{\#}$ coal seam quickly and effectively.

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