

Research on the Experiment Analysis of Spontaneous Combustion Characteristics of the 15# Coal Seam in Fusheng Coal Mine

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ABSTRACT

According to the spontaneous combustion characteristics of 15# coal seam in the Fusheng mine, the programming temperature rising test with the coal sample from Fusheng coal mine was conducted, which researched the concentration and the corresponding pyrolysis temperature of index gas during programming temperature rising of the coal sample. The index gases included the CO, CO₂, CH₄, C₂H₄, C₂H₂ and so on.

KEYWORDS

Fusheng Mine; 15# Coal Seam; Coal Seam Spontaneous Combustion Characteristics; Programming Temperature Rising; Index Gas.

1. INTRODUCTION

The Fusheng mine field is located on the eastern edge of the Qinshui coalfield, belonging to the southern section of the Yangquan mining area. The bedrock in the mine field is well exposed, and the valleys are mostly covered by Quaternary loess. The main coal seam that can be mined in the mine field is the 15# coal seam, with an average length of 9.46 meters. Coal dust poses an explosion hazard. The oxygen uptake of coal seam 15 is 0.64 cm³/g, and the spontaneous combustion tendency of coal is classified as Class II. The shortest natural combustion period tested in the experiment is 91 days. However, in the actual mining process, there is a high risk of spontaneous combustion, which is very similar to the ignition characteristics of the mining mine of Yangmei Group, which belongs to the same 15# coal seam. The main reason for this phenomenon is closely related to the mineral water green alum contained in the coal seam. Water green alum is particularly prone to oxidation and is dispersed in the coal seam and direct roof, which can easily lead to spontaneous combustion accidents in the 15# coal seam.[1-2]

The prediction and forecasting of mine fires is an important part of mine fire prevention and control. During the heating process, coal will decompose into different gases, and the temperature and amount of thermal decomposition of each gas are closely related to the coal quality. Therefore, through experimental research on the pyrolysis characteristics of the characteristic gases during the spontaneous combustion process of the coal seam in Fusheng Mine, it is extremely important to select the characteristic gases suitable for the spontaneous combustion characteristics of the 15# coal seam in Fusheng Mine for early prevention and targeted preventive measures.

2. RESEARCH STATUS OF CHARACTERISTIC GASES FOR COAL SPONTANEOUS COMBUSTION

The main indicator gases that can be used for coal spontaneous combustion both domestically and internationally are CO, C₂H₆, CH₄, C₂H₄, C₂H₂, and their auxiliary characteristic gases. The selection of indicator gases for coal seam spontaneous combustion includes selecting appropriate categories, concentrations, and temperature ranges for pyrolysis, and providing prevention and control suggestions for early prediction and forecasting of mine spontaneous combustion.

Experimental research was conducted in accordance with the national standards for the selection of natural combustion marker gases for coal seams. The selection of natural combustion marker gas indicators includes determining the applicable types of marker gases, indicators, and temperature ranges for their use, and providing guidance for prediction and warning. The inspection of marker gases mainly includes CO, alkanes, alkenes, and alkynes. The examination of marker gases includes: (1) concentration of marker gas components; (2) Rate of increase in gas concentration; (3) Mark the critical temperature at which gas is generated; (4) Alkane ratio and its peak temperature; (5) Alkylene ratio and its peak temperature; (6) Characteristic temperature ranges and marker gases for each oxidation stage [3-5].

The principles for selecting marker gases include: (1) CO, C₂H₄, and C₂H₂ reflect to some extent the three stages of slow oxidation, accelerated oxidation, and intense oxidation of spontaneous combustion. Therefore, when selecting marker gases, the applicability of these three marker gases and their indicators should be given priority consideration; (2) When the coal seam contains a high amount of heavy hydrocarbon components in the gas, the influence of heavy hydrocarbon release time and its applicability should be considered when applying the alkane ratio and alkene ratio. Low degree of metamorphism lignite, long flame coal, gas coal, and fat coal should be given priority consideration to olefins and olefin to alkane ratio marker gases and their indicators. For coking coal, lean coal, and lean coal with moderate degree of metamorphism, priority should be given to CO, alkane, and alkene ratio marker gases and their indicators. High degree of metamorphism smokeless coal should prioritize CO and its derived indicators.

3. INDUSTRIAL ANALYSIS AND SPONTANEOUS COMBUSTION TENDENCY TEST RESEARCH OF 3# 15# COAL SEAM

The relevant experimental characteristics of the 15# coal seam coal sample collected from Fusheng Mine were tested and studied. The main content of the test included the moisture, ash content, and volatile components in the coal, and the fixed carbon was calculated. The self ignition tendency identification test result was Class II self ignition, and the coal dust was explosive. During the mining process, there have been signs of local high-temperature oxidation in the mine. The main reason for this is the close relationship between the presence of pyrite and water green alum in the coal seam. During the mining process, local high temperature points and spontaneous combustion are prone to occur, mainly due to the presence of minerals such as water green alum in the coal seam that are prone to spontaneous combustion. Water green alum dispersed in coal seams and direct roofs is a transitional mineral formed during the oxidation process of pyrite. Water green alum exposed to air is prone to chemical reactions, releasing a large amount of heat, which has a significant impact on the spontaneous combustion and heat storage of coal. Therefore, during the mining process, the direct collapse of the mine into the goaf can easily cause spontaneous combustion and fire in the goaf, which should be highly valued.

4. EXPERIMENTAL STUDY ON SPONTANEOUS COMBUSTION CHARACTERISTICS OF COAL SEAM 4# 15#

4.1. Experimental setup

The experimental research system for coal seam spontaneous combustion includes a coal sample tank, preheating gas path, gas analyzer, temperature and gas mass flow controller control system, program temperature control box, etc.

4.2. Experimental Process

4.2.1. Coal sample collection and processing

The coal samples collected according to relevant specifications are sealed and transported to the coal sample analysis laboratory. The coal sample is extracted at the underground mining location, and after selection, the oxidized surface is removed. Then, the laboratory equipment is used for crushing and screening, and 50 g of coal sample with particle size ranging from 40 to 80 mesh is selected as the experimental coal sample.

4.2.2. Experimental process

Place the sieved coal sample in a coal sample container and place the container in a temperature control box (which can be programmed to heat up). Then, connect the inlet and outlet air paths and temperature probes, and check the air tightness of the air path. At the beginning of the experiment, 50 ml/min of dry air is first introduced into the coal sample in the temperature control box, and the coal sample is heated according to the specified temperature rise program. When the specified experimental temperature is reached, the temperature in the program control box is kept constant for 55 minutes, and the characteristic gas released from the coal is collected and analyzed for gas chromatographic composition and concentration.

4.3. Experimental analysis of self ignition characteristic gases in coal seam 15

By analyzing the gas composition of coal samples from the 15# coal seam of Fusheng Mine, the gas evolution trends shown in Figures 1 and 2 were obtained: CO and CO₂ appeared in the coal samples between 30°C and 190°C, and showed an exponential upward trend with increasing temperature; The coal sample exhibits C₂H₄ and C₂H₆ at 110°C, while the gas release of C₃H₈ is evident at 120 °C, and its generation is exponentially related to temperature; CH₄ appears at 60 °C, and its production is proportional to the increase in temperature. From the figure, it can also be seen that when the temperature of the coal body is 40°C, CO begins to decompose and precipitate from the coal. The amount of gas precipitated below 80 °C is relatively small, but as the temperature increases, especially when the temperature is between 80°C and 90°C, the amount of CO generated sharply increases, indicating that the coal body has entered the rapid thermal decomposition stage. At this time, the effect of physical adsorption on coal is weakening, and the coal body has entered the chemical adsorption and chemical reaction stage; C₂H₄ and C₂H₆ appeared at 110°C, indicating a strong chemical reaction between coal macromolecules and oxygen; C₃H₈ appeared at 130°C, indicating that the coal had undergone intense oxidation reaction after 130°C; However, C₂H₂ did not appear between 30°C and 190°C, indicating that it appeared at temperatures higher than 190°C.

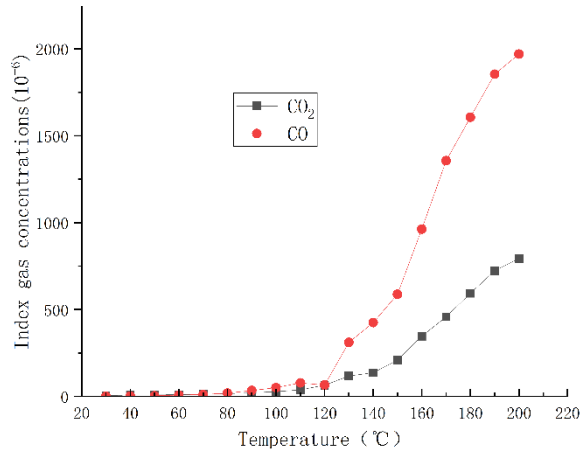


Figure 1 Trend Chart of CO, CO₂ and Changes in Coal Samples

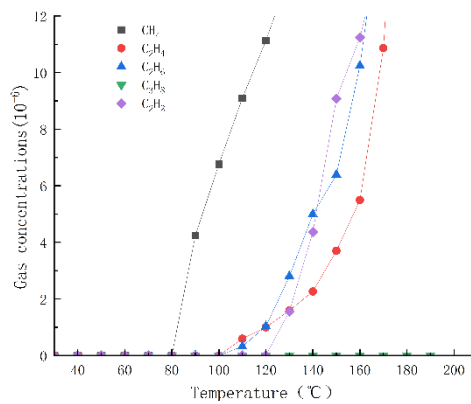


Figure 2 Trend of hydrocarbon gas changes in coal samples

From the above experiments and data analysis, the following conclusions can be drawn: CO gas is the main indicator gas in the 15# coal sample; C₃H₈, C₂H₄, and C₂H₆ are auxiliary indicator gases; The appearance of CO indicates that the coal has entered a slow oxidation stage; The release of C₂H₄ and C₃H₈ gases occurs above 110°C, while the release of C₂H₂ gas occurs above coal temperature of 190°C; The relative amount of CO gas released from coal can reflect the different stages of coal oxidation self heating; If the concentration change of CO gas during oxidation and decomposition is small, it indicates that the coal temperature has not exceeded 90°C. If the rate of CO gas release concentration change gradually accelerates, it indicates that the coal temperature has exceeded 90°C.

5. CONCLUSION

(1) The iconic gases for coal spontaneous combustion in China currently include CO, C₂H₆, CH₄, C₂H₄, C₂H₂, and other indicators. By analyzing the selection principles of marker gases for the 15# coal seam in Fusheng Mine and the occurrence patterns of marker gases during the temperature oxidation experiment of coal samples, the following conclusions are drawn: Within the temperature range of 30-110 °C, CO can be chosen as the marker gas for this temperature range;

(2) Between 110-130 °C, due to the good sensitivity of C₂H₄, once C₂H₄ is discovered, it can be determined that the thermal storage oxidation of coal has entered the accelerated oxidation stage; When the temperature of coal exceeds 130°C, C₃H₈ is used as the characteristic gas for coal thermal decomposition within this temperature range. Once C₃H₈ is discovered, it can be determined that the self heating temperature of the coal seam has reached 130°C.

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