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Fire Extinguishing Technology Ssing Borehole Drilling In Closed Fire Zones of Coal Mines

Yu Hao

Chongqing Vocational Institute of Engineering, Chongqing 402260, China

ABSTRACT

In order to provide a channel for centralized injection of gas or sealing materials from the ground to the underground fire zone, and thus achieve safe mining of the underground 708 working face. Five fire extinguishing boreholes and one monitoring borehole were drilled on the construction ground of the west wing coal seam of Mount Huangshan Coal Mine, and comprehensive fire extinguishing measures such as injecting liquid CO, injecting fly ash, yellow sand, green sand, loess and LFM light filling materials were taken, with a total plugging space of 877.8m3. The monitoring results show that the fire area of the+708 working face has been extinguished, indicating that the drilling fire extinguishing technology adopted has played a good role in controlling the closed fire area of the underground 708 working face.

KEYWORDS

Coal mine enclosed fire zone; Construction drilling; Comprehensive fire extinguishing

1. INTRODUCTION

The results of the fifth coalfield fire area survey in Xinjiang show that as of the end of 2019, there were 40 untreated fire areas in Xinjiang, with a total fire area of 477 730000 square meters, with an annual combustion loss of 456 160000 tons of coal, with an annual emission of greenhouse gas CO_2 reaching 1204 260000 tons [1]. Most coal seams in Xinjiang are thick, steeply inclined, and shallowly buried. The mining of extremely thick and steeply inclined coal seams often causes damage to shallow coal seams and even exposed coal seams [2, 3]. Once the goaf burns, coal fires can easily spread upwards along the coal seams, igniting exposed coal and forming complex coalfield fire zones where mine fires and surface fires coexist [4-5]. The coexistence type coalfield fire zone combines the characteristics of intense combustion and multiple open flame points in the outcrop type fire zone, as well as the characteristics of deep combustion and complex underground air supply conditions in the large mining goaf type fire zone. It is difficult to control and prone to recurrence [6-7]. In addition, shallow outcrop fires and deep goaf fires in coexisting fire zones often form a connection. Deep goaf fires not only provide ignition conditions for shallow coal seams, but also provide some air supply for shallow coal fires through concealed tunnels and cracks connecting the goaf, making the combustion of shallow outcrops in coexisting fire zones more intense than in general outcrop fire zones [8-9].

Great Mount Huangshan Coal Mine is facing the mining dilemma under the coexistence of deep underground fire area and front surface fire area. How to successfully manage and safely unseal the spontaneous combustion area in the closed fire area of the 708 working face in the west wing in combination with the specific conditions of the mine plays an important role in the mining of the medium and large groove coal seams in the west wing and the integrated prevention and control of spontaneous combustion.

2. GEOLOGICAL OVERVIEW OF COAL SEAM IN MINE

Well 1 of Mount Huangshan Coal Mine is located 120km east of Urumqi and 60km away from Fukang City, under the jurisdiction of Fukang City, Changji Hui Autonomous Prefecture. The strata distribution of Mount Huangshan Coal Mine is controlled by the inversion of Ergonghe Mount Huangshan. The middle part (syncline core) is the coal bearing stratum of Badaowan Formation (J1b) of Lower Jurassic of Mesozoic, and the north and south sides (wings) are the Triassic (T) of Mesozoic and the upper Permian (P2) of Paleozoic in turn. Distributed in a strip like pattern northwest of each stratum. The Quaternary Upper Pleistocene and Holocene (Q3-4) of the Cenozoic era are distributed in river valleys, terraces, and mountain front areas. This area is located in the northwest of Dalongkou Sag (IV 5), the second polar structural unit in the east of Urumqi piedmont depression (III 2), and the east end of Ergonghe Mount Huangshan inverted tilt. Under the control of the reverse to oblique direction, the core is composed of the Badaowan Formation of the Early Yanshan sub tectonic layer, and the north and south wings are composed of the Permian and Triassic systems above the Huaxi Indochina tectonic layer.

There are 6~11 coal seams in Badaowan Formation of Mount Huangshan Mine Field, including 6 minable (mostly minable and partially minable) coal seams and 5 non minable coal seams. The thickness of the mineable coal seam ranges from 0.97 to 26.31m, with an average cumulative thickness of 37.08m. The coal seams that can be mined from top to bottom are: five foot groove, four foot groove, meter foot groove, medium and large groove, eight foot groove, and three foot groove. Among them, Zhongda Trough is a thick coal seam with stable stratigraphy and wide distribution, accounting for 78% of the total coal seam resources/reserves in the entire area, mainly mining coal seams; The thickness and stratigraphic stability of the coal seams in the five foot and eight foot troughs are also suitable for mining in the entire area; Four foot groove and meter foot groove are relatively stable, and most coal seams can be used.

3. DRILLING ENGINEERING

3.1. Main Equipment and Drilling Technology

According to the geological characteristics and quality requirements, the fire extinguishing drilling for this construction adopts air circulation drilling, with main equipment including DL-700 drilling rig, AtlasVFCY-21/20 air compressor, etc.

Adhering to the principle of promoting safe and efficient drilling, and fully sealing the fractured zone to prevent drilling accidents. The hole adopts a diameter of Φ 311mm to pass through the upper loose layer, and a diameter of Φ 245mm surface casing is inserted below; The second opening adopts a diameter of Φ 215mm, drilling to 5m below the expected meter slot coal seam, and inserting a Φ 180mm casing; Three openings with a diameter of Φ 152mm are used to drill into the final hole.

3.2. Drilling Structure

According to the geological characteristics revealed by drilling, the actual rock layers encountered during drilling are mainly sandstone, siltstone, mudstone, conglomerate, coal seam, and goaf. The drilling construction adopts a three hole drilling structure.

(1) First opening: Use a Φ 311mm down the hole hammer drill bit to pass through the upper cover layer, and insert a seamless casing of Φ 245mm×8.0mm, followed by manual cement slurry cementing;

(2) Second opening: Use a Φ 215mm down the hole hammer drill bit for drilling, insert a seamless casing of Φ 180mm×6.0mm, and use manual cement slurry for well cementing;

(3) Triple opening: Use a Φ 152mm down the hole hammer drill bit to drill until the final hole is drilled. After the final hole is drilled, insert a Φ 108mm×6.0mm seamless casing (with a sieve tube at the bottom 20m).

According to the requirement of the inner diameter of the casing to be greater than 115mm in the design of Jian 05 borehole, combined with the geological characteristics revealed by Jian 01 borehole, Jian 05 borehole adopts a double opening construction structure. At first, a Φ 254mm down the hole hammer drill bit is used to pass through the upper cover layer, and a seamless casing of Φ 219mm×6.0mm is inserted for manual cement slurry cementing; The second opening is drilled using a Φ 165mm down the hole hammer drill bit, and a seamless casing of Φ 127mm×6.0mm is inserted (with a screen pipe at the bottom 2m), followed by manual cement slurry cementing.

3.3. Completion of Engineering Review

The dip angle of the strata in the west wing of the coal mine is relatively large (about 44°), and anti inclination measures were taken during the drilling process to control the hole inclination from exceeding the limit; The drilling construction passes through the upper minable coal seam and goaf, and the final drilling layer is the collapse zone of the middle and large groove roof. During the drilling process, cracks, voids, and cavities are encountered. A total of 5 fire extinguishing boreholes have been constructed, with a cumulative drilling depth of 959.45m.

4. CONTROL THE UNDERGROUND FIRE AREA THROUGH SURFACE DRILLING

4.1. Drilling Fire Extinguishing Measures

(1) According to the actual space of the closed area roadway and goaf in the west wing, the volume of the closed area space in the west wing is 614700 m^3. Calculated based on the liquid CO_2 vaporization rate of 640 times, the actual volume of CO_2 filled space is 1.339 million m^3, which is 2.2 times the actual volume of the closed area in the west wing. A total of 21700 tons of liquid CO_2 were injected, including 620 tons from borehole Jian 01, 540 tons from borehole Jian 02, and 120 tons from borehole Jian 03.

(2) Inject 26t (33m3) of fly ash, 221.92 t (106m^3) of yellow sand, 558t (328m^3) of green sand, 40t (26m^3) of loess, 28 t (280 m^3) of LFM lightweight filling material, and 178.16 t (104.8m^3) of stone powder into hole No. 05, with a total sealing space of 877.8 m^3. The actual filling space is more than twice the expected filling space (303 m^3).

(3) After sealing the lower end of the+708 working face using borehole No. 05, water, yellow mud, fly ash, etc. were injected into boreholes No. 01, No. 02, and No. 04 to cool down and cover the corresponding hidden fire areas.

4.2. Effect Evaluation

(1) The relevant parameters in borehole 6 were tested, and the air temperature inside the borehole measured at a depth of 160m was 13.3℃; No sand or slurry was found at the bottom of the borehole at 230m. The main purpose of this borehole is to monitor the sealing of the lower end of the+708 working face by the injection of fire prevention and extinguishing materials into the No. 05 borehole. As shown in Table 3, no CO gas was detected in this borehole during this time period, indicating that there are no high temperature or fire points at the location of the borehole or the+708 working face.

(2) The drilling has been monitoring the parameters related to the+708 working face since April 16th, but no C_2H_4 or C_2H_2 gas has been detected.

Table 1. Changes in gas data related to borehole No. 06

Serial Number	CH_4 %	C_2H_6 PPm	C_2H_4 PPm	C_2H_2 PPm	O_2 %	N_2 %	CO PPm	CO_2 %
1		0	0	0	20.11	78.32	0	0.05
2	0.03	0	0	0	20.37	78.47	0	0.07
3	0.02	0	0	0	20.12	77.79	0	0.06
4		0	0	0	20.13	78.92	0	0.06
5		0	0	0	20.11	78.32	0	0.05
6	0.06	0	0	0	20.3	75.66	0	0.06
7		0	0	0	19.87	76.05	0	0.04
8	0.03	0	0	0	19.75	78.09	0	0.07
9	0.02	0	0	0	19.62	77.91	0	0.07
10	0.001	0	0	0	19.65	79.46	0	0.05
11	0.02	0	0	0	19.5	78.3	0	0.06
12	0.02	0	0	0	20.44	77.61	0	0.06
13	0.01	0	0	0	20.29	77.84	0	0.05
14	0.009	0	0	0	20.4	78.47	0	0.05
15		0	0	0	20.44	78.85	0	0.1
16	0.005	0	0	0	20.34	77.78	0	0.04
17		0	0	0	20.25	76.66	0	0.05
18	0.0004	9	0	0	20.06	78.25	0	0.04
19	0.002	0	0	0	20.25	77.27	0	0.05
20	0.01	0	0	0	19.97	78.35	0	0.07
21	0.01	4	0	0	20.95	76.56	0	0.08
22	0.07	20	0	0	20.97	77.47	0	0.15
23	45.67	2400	0	0	9.63	37.65	0	4.31
24	46.68	2500	0	0	9.07	35.55	0	3.82
25	0.02	4	0	0	19.54	77.97	0	0.08
26	0.007	0	0	0	20.9	78.71	0	0.06
27	60.47	2700	0	0	8.88	34.41	0	3.97
28	58.75	2600	0	0	8.28	27.71	0	4.14
29	0.07	200	0	0	21.34	77.11	0	0.08
30	70.17	7500	0	0	8.48	15.65	0	3.84
31								
32	74.18	2500	0	0	7.89	29.68	0	4.23
33	67.73	2400	0	0	7.86	19.78	0	4.3
34	69.88	2600			7.13	17.13		4.61
35	59.2	2500	0	0	7.41	28.77	0	4.76
36	58.36	2400	0	0	7.92	28.54	0	4.79
37	54.07	2300	0	0	8.91	32.76	0	4.03
38	54.37	2300	0	0	9.1	32.51	0	3.79
39	53.56	2300	0	0	8.87	32.29	0	4.09
40	55.79	2400	0	0	8.27	31.23	0	4.47

5. CONCLUSION

(1) The construction of fire extinguishing boreholes in the western wing of the coal mine passes through the upper minable coal seam and goaf, and the final borehole level is the collapse zone of the middle and large groove roof. During the drilling process, cracks, gaps, and voids were encountered,

and a total of 5 fire extinguishing boreholes and 1 monitoring borehole were completed, with a cumulative drilling depth of 959.45m.

(2) Taking comprehensive fire extinguishing measures: injecting 21700 tons of liquid CO_2, injecting 26 tons of fly ash, 221.92 tons of yellow sand, 558 tons of green sand, 40 tons of loess, 28 tons of LFM lightweight filling material, and 178.16 tons of stone powder, a total of 877.8 cubic meters of sealed space. After sealing the lower end of the+708 working face using borehole No. 05, water, yellow mud, fly ash, etc. were injected into boreholes No. 01, No. 02, and No. 04 to cool down and cover the corresponding hidden fire areas.

(3) Through comprehensive analysis of the relevant parameters in the ground drilling monitoring borehole 06 #, it is determined that the fire zone in the+708 working face has been extinguished.

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