Journal of Applied Science and Engineering Innovation, Vol.7, No.3, 2020, pp. 132-135
ISSN (Print): 2331-9062
ISSN (Online): 2331-9070

Research on Fire Extinguishing Technology of High Gas Flammable Fully Mechanized Caving Face in Retreat Period

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Abstract: Based on the three zones measurement results of the spontaneous combustion in the fully mechanized caving face of coal mines and the risk analysis of spontaneous ignition, for four different stages during the mining and withdrawal period of the high gas flammable fully mechanized caving face, ventilation system and extraction volume adjustment of working face, low-temperature nitrogen injection in goaf, perforated grouting within 15m of upper and lower corners to block air leakage channels, holes between the brackets are filled with fire retardant inhibitors and blocked behind the racks, boreholes are injected with inhibitors in abnormal areas, and spontaneous fire monitoring in goafs and other comprehensive fire-fighting technical measures were proposed. After the implementation of comprehensive fire prevention and extinguishing technology measures, the main indicator gas concentrations did not exceed the standard during the production stoppage of the face, and no signs of spontaneous combustion occurred in the mined-out area, which ensured the safe and rapid one-time withdrawal of the face.

Keywords Coal mine, Easy spontaneous combustion coal seam, Fully mechanized caving face, Retreat period, Fire extinguishing technology

INTRODUCTION

Mine fire is one of the five major disasters in coal mines. Fire prevention and control in mines with high gas spontaneous combustion is a key point in the prevention of major mine accidents [Cheng, 2015, Wang, et. al., 2017 and Zhao, et. al., 2016]. During high-gas and easy-fired coal seam fully mechanized caving face during coal mining and withdrawal, due to slow advancement and long period, the coal left in the goaf is affected by factors such as air leakage oxidation and heat storage, and it is prone to spontaneous fire accidents, leading to face equipment unable to withdraw normally, causing significant economic losses and waste of resources, and it is very easy to induce gas and coal dust accidents, which seriously threatens the personal safety of on-site operators [Sun, 2019 and Xu, et. al., 2017].

In recent years, more and more scholars have conducted in-depth research on this issue. Jiang Yanshi, et al. analyzed a series of fire prevention technical measures and effects such as plugging, nitrogen injection, drilling and grouting during the unsealing and withdrawal of the S1W1 fire area of Xiaokang Mine [Jiang, et. al., 2001]. Ren Wanxing, et al. proposed the pressure equalization fire extinguishing technology implemented in stages to solve the coal spontaneous combustion problem during the removal of the 9421 fully mechanized coal face in Zhangshuanglou Coal Mine [Ren, et. al., 2016]. Cui Jie at the II020205 fully mechanized caving face in Yangchangwan Coal Mine, implements comprehensive fire-fighting technical measures, mainly including that up and down the shaft to block the air leakage channel, spontaneous combustion monitoring in the goaf, adjacent tunnels and measure lanes, the corresponding support boreholes are filled with liquid CO_2, the face is injected with water [Cui, 2018]. Fan Baotong, et al. also proposed the use of pressure injection gel in working face, low temperature CO_2 injection in deep drilling, filling LFM light filling material in leaking roof area and other measures for fire prevention during the withdrawal of fully mechanized caving face in thick coal seam [Fan, et. al., 2020].

Shanxi Lu'an Group Heshun Liyang Coal Industry Company, with a designed production capacity of 1.2 million tons per year, are high-gas mines with severe spontaneous combustion. They are mainly mining the 15# coal seam of the Taiyuan Group with a coal thickness of about 5.76m. 15# coal seam spontaneous combustion tendency is Class I easy spontaneous combustion coal seam, the shortest ignition period is about 31 days. Since the establishment of the mine in Liyang Coal Industry, spontaneous combustion of coal has occurred many times during the work mining or shutdown period, which has had a serious impact on the safe production of the mine. Therefore, adopting effective fire prevention and extinguishing technology measures to ensure the safe and smooth withdrawal of fully mechanized caving face is the focus of fire prevention and control at the face and also the most important part of mine safety management.

RISK ANALYSIS OF SPONTANEOUS COMBUSTION DURING COAL MINING AND WITHDRAWAL IN FULLY MECHANIZED CAVING FACE

Risk analysis of spontaneous combustion during coal mining

(1) Geological occurrence conditions. The 15# coal seam in the mining area and the 14# coal seam about 8m above are all Class I easily spontaneously ignited coal seams with high sulfur content and 14# coal seam contains phosphorus. After the working face is promoted, a large number of easy-to-natural floating coals are left in mining empty area.

(2) Working face mining technology. Restricted by the ending and end mining technology, the reinforced steel mesh is reinforced and supported 20m before the stop of the fully mechanized caving face, and the coal is stopped to ensure the roof is intact. In this way, the recovery rate is relatively low, and a large amount of floating coal remains in the goaf space, which provides combustible materials for natural ignition.

(3) Air leakage in goaf. The wind and transport lanes of the working face are supported by anchor nets and cables. After the frame is moved, the upper and lower corners of the roof cantilever have a large ceiling area, which is not easy to collapse, resulting in a large air leakage in the goaf, which provides combustion aids for natural ignition.

(4) Advance speed. The working face enters the coal mining stage, the recovery speed is slow, and the floating coal left in the goaf is oxidized for a long time, which provides continuous accumulation of heat for natural ignition.

Risk analysis of spontaneous ignition during the retracement

(1) Leftover coal in goaf. The shortest spontaneous firing period of 15# coal seam is 31d, and the shortest spontaneous firing period of 14# coal seam is 18d. However, the perimeter of stop mining and withdrawal of working face is longer, which is often more than 1 month. The oxidation is further exacerbated. When the energy accumulated in the goaf exceeds a certain critical value, spontaneous combustion is extremely likely to occur.

(2) Crushed coal at the top. The withdrawal time of the support on the working face is about 1 month. The oxidation time of the floating coal on the top of the support is longer, which is easy to accumulate heat and then induce spontaneous combustion.

(3) Floating coal at the rear. The working face is to be laid with flexible steel mesh, control the flow of high pumping lanes, and grouting behind the rack to block air leakage and other measures before stopping mining and removing racks. After the implementation of measures such as reducing working air distribution, controlling extraction flow and blocking air, the width of the heat sink in the goaf is further compressed, and the oxidation zone moves forward, which is behind the goaf. Oxidative heat storage of floating coal provides favorable conditions and is more likely to spontaneously ignite.

FOUR PHASES OF FIRE PREVENTION AND EXTINGUISHING TECHNICAL MEASURES DURING MINING AND WITHDRAWAL OF WORKING FACE

Take fire extinguishing technical measures within 25m from the stop line during the closing period

(1) The corner is blocked. With the mining of the working face, the upper and lower corners are blocked with woven bags of coal at 8 o'clock every day, and the edge gaps are filled with yellow mud. Then, a 1-inch flower tube is inserted within 15m of the corners, the top is cut, and the goaf is inserted 5m injection of Staf (inorganic fire extinguishing material) slurry forms a wind curtain at the upper and lower corners to reduce air leakage in the goaf, as shown in Figure 1.

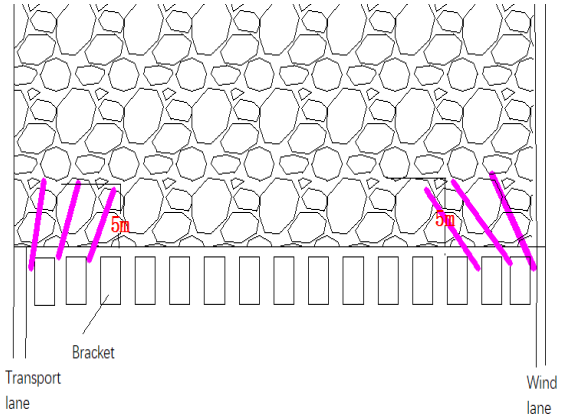

Figure 1. Schematic diagram of corner cannula grouting

(2) Continuous nitrogen injection at low temperature. Lay an injecting pipeline (⌀80mm) at a distance of 50m away from the stop line along the cut hole and set a gas outlet every 30m. The transportation lane is equipped with a nitrogen refrigeration device, which can cool the nitrogen injected into the well to -25℃ and inject it into the goaf.

(3) Lay the air duct cloth on the top of the bracket. When the working face is 12m away from the stop line, the top of the support is supported by a double-layer rolled net, and the two layers of rolled nets are sandwiched between the air cylinder cloth (10×1.1m). By laying the air cylinder cloth, the falling of the floating coal at the rear of the support is reduced. The oxygen contact area delays the oxidation rate of the floating coal behind the rack.

(4) Normal low temperature nitrogen injection. During the closing period, continuous and continuous low-temperature nitrogen injection is adopted at the inlet corner to reduce the oxygen content in the mined-out area, so as to reduce the oxidation rate of the coal left in the mined-out area.

Take fire-fighting technical measures during coal mining

(1) Change the ventilation system and adjust the extraction volume (as shown in Figure 2). After the stoppage of the working face, withdraw the rear slip and three sets of end frames, and build a 2m thick seal at a distance of 8m from the cut hole of the roadway to form a local positive pressure ventilation between the roadway and the cutout. The flow rate of the high pumping lane is controlled from 300m^3/min to about 60m^3/min, and the extraction volume at the upper corner is controlled at 20m^3/min. In this way, the air supply in the mined-out area is reduced, and the area of the oxidation zone is reduced.

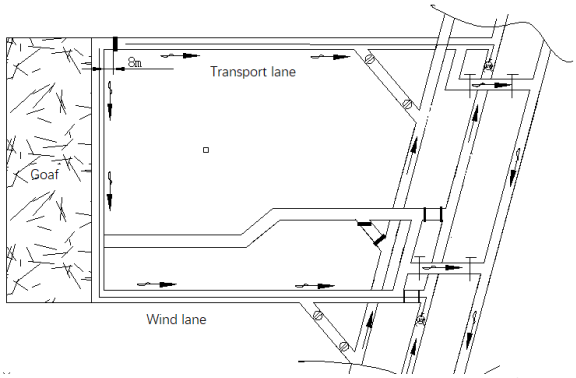

Figure 2. Ventilation system diagram during working face withdrawal

(2) Punch and grouting behind the bracket. After stopping mining, retract the side shields of the support, and use the bolt machine to connect the hollow drill rod to the top of each two sets of supports to drill holes. Injecting Staf slurry into the mined-out area through drilling holes to form a windshield curtain within 3m behind the support to reduce air leakage in the mined-out area. Then spray all the Staf slurry on the coal wall behind the support to cover the exposed coal body behind the support to inhibit the oxidation of the coal left behind the support.

Take fire-fighting technical measures during the withdrawal

(1) Dismantle the collapsed coal body. Every time the working face withdraws a set of brackets, it uses Staf anti-extinguishing materials to fully cover the collapsed area. Then use a flower tube with a length of 4m and 6m (with 8~10 holes with a diameter of 1cm in the range of 1m at the end and flatten the end) to inject grouting into the collapsed area until the bottom of the collapse has slurry infiltration. Inhibit the oxidation of collapsed coal.

(2) Handle the CO abnormal area on the top of the bracket. During the withdrawal of the working face, CO appeared on the top of some of the supports, especially near the location of the high extraction lane. The fan-shaped piercing sprinkler holes arranged at the position of 30m from the cutting eye of the wind and transportation lanes to the cutting eye were used to face the CO abnormal area with leaching inhibitor (calcium chloride), as shown in Figure 3. The CO abnormal area between the supports generally appears at the top of the middle part of the two tail beams, and the STF anti-extinguishing slurry is injected from the cantilever of the front beam to the area of the rear tail beam. The two measures are used together to suppress the coal body oxidation at the top of the support.

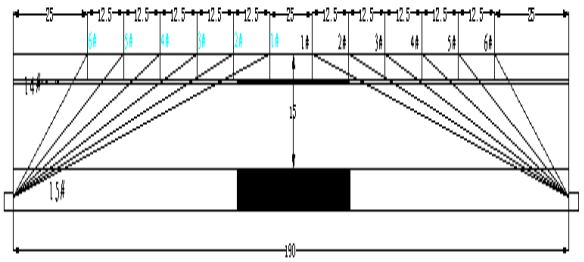

Figure 3. Fan-shaped water spray hole arrangement

(3) Liquid CO_2 is injected in the goaf. Considering the longer retreat time, the 15# coal seam and the 14# coal seam in the upper adjacent layer are all spontaneously combustible coals. After the air volume and extraction volume of the working face are controlled, the oxidation zone of the goaf moves forward to prevent the oxidation zone from being left behind. Coal spontaneous combustion, using nitrogen injection pipeline reserved 20m away from the cutout stop line, continuous low-temperature nitrogen injection, intermittent injection of liquid CO_2 into the goaf, effectively suppressing spontaneous spontaneous combustion.

(4) During the retreat, use beam tubes laid at the corners to extend into the goaf 50m and 30m, and use surface chromatography and underground moving beam tubes to closely monitor the spontaneous ignition gas index of the goaf. Manual inspection and gas sampling chromatographic analysis are used on the top of the support and the back of the support to keep abreast of the oxidation status of the coal body and take active measures.

Take fire-fighting technical measures after closing

(1) Temporary closure. When withdrawing the remaining three sets of end frames, the three sets of frames will be pulled to the wind lane 8 meters away from the cut-out at the fastest speed, and a 2m-thick closed wall will be built at a position close to the cut-out 8m, so that the working face is formed closed area as soon as possible.

(2) Strengthen note Sui. Continue to inject CO_2 or low-temperature nitrogen through the closed pre-buried Sui injection pipe on the air inlet side, stop the extraction until the oxygen concentration on the return side drops below 8%, and continue to observe the changes of other indicator gases.

(3) Permanent closure. After all the last three sets of tailstocks and other equipment on the side of the wind tunnel are withdrawn, a permanent closed wall

is constructed at the entrance of the wind tunnel for permanent closure. During the period, the low-temperature nitrogen injection is continuously injected into the goaf to ensure that the oxygen concentration in the goaf is below 5%, no CO appears, and the injection can be stopped for a week.

CONCLUSION

During the closing and withdrawal period of fully mechanized caving face, different pre-control measures for fire extinguishing are adopted in four stages. The above comprehensive measures for fire extinguishing are implemented scientifically and rigorously, which ensures that the working face equipment is smoothly withdrawn and closed within 23 days, achieving a one-time rapid withdrawal of high-gas easy-ignition fully mechanized caving face. It provides valuable experience for fire prevention and management during the withdrawal of high gas and easy natural fully mechanized coal mining face.

REFERENCES

Cheng Wei-min. Mine ventilation and safety [M]. Beijing: Coal Industry Press, 2015

Cui Jie. Fire prevention and extinguishment technology during the end mining and withdrawal of spontaneous combustion coal face[J]. Coal Mine Safety, 2018,49(6): 54-57+61.

Fan Bao-tong, Li Jing, Guo Yu-yin. Research on fire prevention and extinguishing technology during withdrawal of fully mechanized caving face in thick coal seam [J]. Shandong Coal Science and Technology, 2020(5): 98-100.

Jiang Yan-shi, Zhang Wen-yuan, Jiang Xiao-wen, et al. Fire prevention and extinguishing technology for unsealing and retreating in the fire area of S1W1 fully mechanized mining face of Xiaokang Mine [J]. Coal Mine Safety, 2001(10): 5-6.

Ren Wan-xing, Guo Qing, Zuo Bingzhao, et al. Pressure equalization fire extinguishing technology during the withdrawal period of working face of close-range spontaneous combustion coal seam group[J]. Coal Science and Technology, 2016, 44(10): 48-52+94.

Sun Xue-liang. Fire prevention and extinguishing technology and rapid withdrawal technology during the end mining period of working face[J]. Coal Mine Safety, 2019,50(6):78-81.

Wang Shi-wei. Hazards and treatment of mine fires [J]. Inner Mongolia Coal Economy, 2017(Z2): 67+83.

Xu Hong-liang, Shi Chang-kun, Qiao Xiao-hui. Fire prevention and extinguishment technology during the withdrawal of fully mechanized caving face in easily inclined spontaneous coal seam with large inclination angle[J]. Coal Science and Technology, 2017(4):192-194.

Zhao Ya-jun, Xiong Pu, Xue Feng, et al. Development and trend of mine fire prevention and control technology[J]. Coal Technology, 2016, 35(5): 157-160.