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Waste filling technology under condition of complicated geological condition working face

Ju Feng[a,]*, Zhang Ji-xiong[a], Huang Yan-li[a], An Tai-long[b]

[a]*School of Mining Engineering, China University of Mining & Technology, Xuzhou 221008, China*
[b]*School of Sciences, China University of Mining & Technology, Xuzhou 221008, China*

Abstract

With the deep development of mining in China, the problems, such as complicated mining conditions, bad coal result of dirt band and fault, and environmental pollution caused by waste, are more and more serious. In order to dispose waste in underground and ultimately improve the quality of coal, the secerning mining and transporting and waste filling technology and filling equipments were studied, the faultage that was less than mining height and the dirt band that was bigger than 150mm, were secerning mined and transported, and the detached dirt band was filled in the face end triangle by filling equipments. It carries out that the quality of coal is ultimately improved, the assistant exaltation is liberated, and the environmental threat caused by waste is eliminated.

Keywords: secerning mining and transporting; fault; dirt band; filling process; waste packing unit; coal quality

1. Introduction

As mining depth increases in China, geological condition in most coal mining face becomes complicated, the dirt band and fault have formed in coal seam in the process of geological age with small fault in coal seam in most coal mine, the thickness of coal seam is not well-proportioned and the roof of coal mining face belongs to composite roof, thus most wastes produced will be mixed in raw coal. If mined by regular ways, quality of the raw coal will be worsen because of the more waste content, so as to increase the burden to be the assistant hoist and the coal washing yard and reduce the real capability of main shaft. On the other hand, waste transported to ground have badly polluted the environment of coal mine[1].

Based on these problems, the secerning mining and transporting and waste filling technology, which is put forward while encountering the geological structure such as the thin coal district, fault or floor heave and so on, can insure quality of the raw coal in mining face. The technology will secern coal and waste while mining and transporting. Finally, waste produced is backfilled to gob.

2. Principle of the secerning mining and transporting and waste filling technology

* Corresponding author. Tel.:+86-13605218330.
E-mail address: juf1983@163.com.

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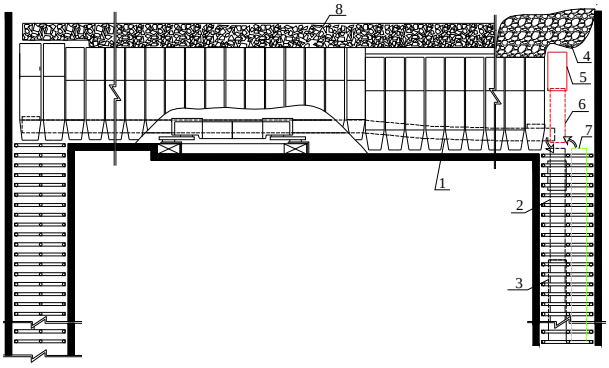
2.1. System arrangement

The secerning mining and transporting and waste filling technology is to apart waste from the raw coal in mining face, and backfill these waste into gob, so as to enhance coal quality and increase the real capability of main shaft. The secerning mining and transporting and waste filling system consist of coal mine transporting system in mining face and waste backfilling system in gob. Secerned coal are transported from scraper conveyer to coal loader, and transported out from belt conveyor. Waste backfilled into gob includes two parts: fault waste or dirt band in coal seam and waste separated from raw coal. Secerned fault waste or dirt band is transported from scraper conveyer to waste loader and backfilled into gob by waste packing unit. After separated from raw coal by separation system, waste is transported from scraper conveyer back to waste loader and backfilled into gob by waste packing unit.

The arrangement of the secerning mining and transporting and waste backfilling system is shown in Fig.1.



1-scraper conveyer; 2-coal loader; 3-belt conveyor; 4-trigonal backfill district; 5-waste packing unit; 6- waste loader; 7-waste scraper conveyer; 8-gob

Fig. 1. Arrangement of the secerning mining and transporting and waste backfilling system

2.2. Technical condition

The secerning mining and transporting and waste backfilling technology can apply to some mining faces, such as geological structure, unsteady thickness or dirt band in coal seam. Especially, it's more important for the fully mechanized coal mining face holding bad coal quality to mine. Technical condition should follow:

(1) The mining face passes fault, whose size is less than or equal to mining thickness;

The usual ways by which fully mechanized coal mining face passes geological structure[2][3]: when the mining face of complicated geological condition encounter the bigger fault and the collapse column, the way of another open-off cut was used to keep mining. For the mining face embodying the smaller fault, the compelling way was used to keep mining.

However, when passing the smaller Fault, we used the compelling way. This method can not enhance coal quality and the mining efficiency, neither ensure safety of the mining face. When the way of another open-off cut was used to keep mining, there will be some disadvantages such as increasing additional investment and occupying the mining time. Not to affect mining and coal quality, the secerning mining and transporting and waste backfilling technology was used to solve these problems in the process of mining.

(2) Containing about the steady dirt band of 1/3 mining thickness in coal seam;

There are lots of dirt band formed in coal seam which was formed in specifical geological age in most coal mine. When thickness of dirt band in coal seam is approximately equal to 1/3 mining thickness, it's necessary for these coal seams to adopt the secerning mining and transporting and waste backfilling technology to improve coal quality and dispose waste into gob.

(3) In the coal seam whose thickness was not well-proportioned;

In the process of mining, as the thickness of coal seam was not well-proportioned so that it's necessary to dig the

top or down rock of coal seam[4][5],so waste quantity in raw coal increased sharply. The secerning mining and transporting and waste backfilling technology was used to dispose waste under mine, enhance coal quality and achieve green mining[6].

(4) In coal mine whose main shaft and assistant hoist were relatively difficult

The real capability of main shaft was a bottle-neck which would restrict the mine to achieve high production and high efficiency in mining face. However, waste mixed in raw coal restricted the real capability of main shaft to improve. If transported to ground, waste would increase the burden of the assistant hoist. So the secerning mining and transporting and waste backfilling technology was used to solve these problems.

3. Principle of the secerning mining and transporting and waste filling technology

3.1. Design of secerning mining and transporting technology in fault and dirt band in coal seam

While the mining face of complicated geological condition came across small fault and dirt band, in order to improve the quality of the raw coal and dispose waste in coal seam, secerning mining and transporting technology was used. According to different rock rigidity, different technologies were used: when the rock rigidity was weak, coal winning machine was used for cutting the rock; when the rock rigidity was hard, loose blasting was used for loosing the rock[7], and then coal winning machine was used for cutting the rock. Waste was backfilled in gob through scraper conveyer, loader, and waste packing unit, and coal was ship out through scraper conveyer, loader, and belt conveyor. Secerning mining and transporting technology was as follows:

(1) Before mining, the productive cycle should be arranged scientifically, and normal cycle busywork should be held. Firstly, coal winning machine cutcoal on top of the fault. Then coal winning machine backpedalled 20m. Finally, the roof must be sustained ahead with support. In the coal seam including dirt band, dirt band should be disposed firstly, then coal seam is mined.

(2) After supports in the fault were examined in the mining face, hydraulic system should be ensured perfectly in order to provide enough support force.

(3) According to the design of blast-hole arrangement, after blast-hole was digged and detonator was loaded, equipments used in the mining face should be protected. At the same time, we should form the backfilling system by the following way: firstly, handpiece of the transporter was driven up in order to make the loader in the belt conveyor laneway move along 2m; secondly, waste packing unit was moved along with loader to join with scraper conveyer in the mining face. After workers were evacuated, loosening blast was put in the mining face.

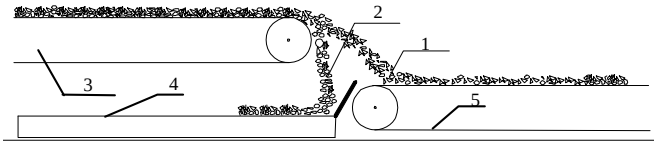
(4) After blasting, blasters must examine blasting condition and clean dunp cannons thoroughly. After disposing the waste in the fault and dirt band in the coal seam, waste packing unit was moved back for 2m. Finally, when the loader was moved to normal position, the workers debased handpiece of the transporter and started to cut coal.

3.2. Separation technology of waste in coal flow

As a result of waste in the raw coal that came from fall of the roof and composite roof, secerning mining and transporting technology could not be used in the mining of coal seam that contained thin dirt band. To improve the quality of raw coal, separation system of waste in coal flow, which was composed of gravity primary separation and movable bed jig separation, was designed in mining area. The separated waste was transported back to gob through scraper conveyer, and then backfilled in the gob by waste packing unit.

(1) Gravity primary separation technology

Based on the different unit weight between coal and waste (for example, 1.4 of coal, 2.5 of waste), the weighty waste and the ethereal coal were popped with different horizontal distance by more than 2.2m/s rate from the handpiece of the transporter. A scraper conveyer for transporting waste and a belt conveyor for transporting coal were installed on point of waste and coal fall. The system of gravity primary separation technology was shown in Fig.2.

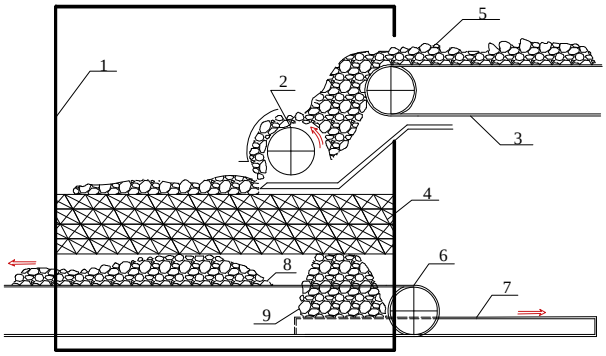


1- raw coal; 2-waste; 3-belt conveyor; 4-waste scraper conveyer; 5-coal belt conveyor

Fig. 2. The system of gravity primary separation technology

(2) Movable bed jig separation technology

Although waste was separated through gravity primary separation, some ratable waste was contained in the raw coal. In order to reduce the waste quantity in the raw coal, movable bed jig was installed in the handpiece of the transporter. The movable bed jig consisted of classification jig, and driving set, etc. When waste and raw coal were transported into high speedy collision equipment, the raw coal was broken up because of different rigidity, but the waste wasn't. They were subjected to the same wallop which could be accommodated by driving set. Then, after the raw coal passed classification jig, the coal fell from sieve pore, and was shipped out by belt conveyor. However, some waste, which was separated in the raw coal, was transported back into scraper conveyer and backfilled into gob. It was shown in Fig.3.



1-movable bed jig; 2-high speed collision equipment; 3-belt conveyor; 4-classification jig; 5-raw coal; 6-coal belt conveyor; 7-scraper conveyer; 8-separate coal; 9-separate waste

Fig. 3. System of movable bed jig separation technology

3.3. Backfilling technology in gob with secerning mining and transporting

(1) Flow of the backfilling technology

Flow of the backfilling technology was shown in Fig.4.

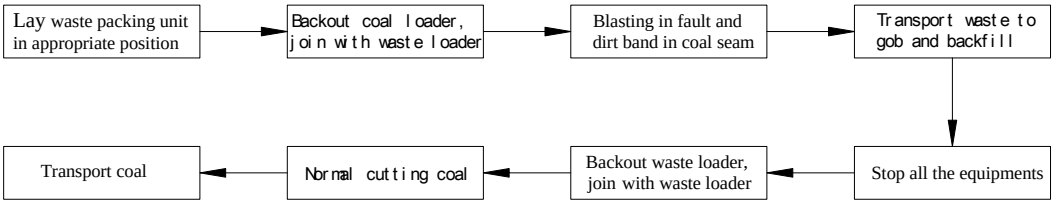


Fig. 4. Backfilling technology flow in gob with secerning mining and transporting

(2) Particular backfilling technology

Backfilling technology in gob with Secerning Mining and Transporting is as follows:

① Before secerning mining and transporting, we should form the backfilling system by the follow way: firstly, handpiece of the transporter was drove up in order to make the loader in the belt conveyor laneway move along 2m;

secondly, waste packing unit was moved along with loader to join with scraper conveyer in the mining face. And also, before waste was separated from the coal flow, scraper conveyer should join firstly with waste packing unit.

② The triangle area should be given fortified support in the mining face. If encountered a little gas, enough area should be kept for waste packing unit by delaying caving the roof of the belt conveyor laneway. For making the waste loader move ahead or backwards, we should timely clear up sundries around the loader.

③ After checking the safety of every equipment, we could start up the waste packing unit, waste loader, coal scraper conveyer and waste scraper conveyer.

④ When the waste was transported to handpiece, waste would be transported to waste packing unit by the waste load and backfilled into the triangle area of gob. If there was agglomerate waste in transportation, all transporting and backfilling equipments should be stopped timely. For keeping the scraper conveyer transporting from a mountain of waste, the loose blasting or a dead lift should be used to achieve the backfilling of gob.

⑤ According to the condition of the gob, the angle and speed of waste packing unit should be adjusted frequently to ensure the backfilling effect.

4. Development of the backfilling equipment with secerning mining and transporting in gob

Generally, in the back of the three supports, which is in conjoined location of gob in haulageway and mining face, there is a triangle roof face whose falling time is later than other parts, 80 cubic meters' lager. The waste, which was mined and transported separately, would be directly backfilled into this space by special device. It can less affect the haulage system caused by waste's out-transportation.

Developing backfilling equipment is the key point of waste's secerning mining and transporting into the gob. Therefore, the waste packing belt is developed to separate backfilling waste mechanically, in accordance with the backfilling characteristics. By the way, the equipment should be designed smally as soon as possible, to meet transportation and installation in underground. In addition, the velocity of packed waste should be seasoned with backfilling process, thus it is easy to move packing unit forward and backwards[8][9].

We do a definition that the inclination of the coal roadway is θ, the height of waste packing unit is h, the initial velocity of packed waste is v_0, the waste velocity at arbitrary point A is v_A, and the vertical distance between point A and packing point O is h_A, as shown in Fig. 5.

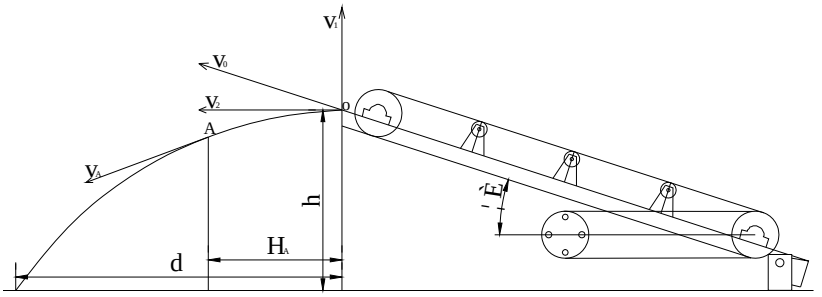


Fig. 5. Model of counting the parameter of waste packing unit by academic way

Based on the energy conservation laws: $(1)/2mv_0^2=(1/2)mv_A^2+mgh_A$, we get:

$$v_A^2= v_0^2+2gh_A \tag{1}$$

For that $v_1= v_0+sin\theta$, $v_2= v_0+cos\theta$, $\theta=arcsinh/5$, we get the vertical component v_1, and horizontal component v_2 of initial velocity v_0:

$$v_1= v_0\times h/5 \tag{2}$$

$$v_1 = v_0 \times \frac{\sqrt{25 - h^2}}{5} \tag{3}$$

For the moving time:$t=d/v_2$, we get vertical displacement h_A:

$$h_A=(1/2)gt^2- v_1t=(1/2)g(d/v_2)^2- v_0\times(h/5)\times(d/v_2) \tag{4}$$

Substitute formula (4) into formula (1), we get the velocity v_A at the arbitrary point A:

$$v_A^2 = v_0^2 + 2g[(1/2)g(d^2/v_2^2) - v_0 \times (hd/5v_2)] \quad (5)$$

Define x as horizontal displacement, y as the ver tical displacement, then we get the kinetic equation of the packing waste:

$$\begin{cases} x = n_2 t \\ y = n_1 t + \dfrac{1}{2} g t^2 \end{cases} \quad (6)$$

Substitute formula (1)、(3)、(4)into formula (6), then we get:

$$\begin{cases} x = \dfrac{d \times v_0 \sqrt{25 - h^2}}{5 v_2} \\ y = \dfrac{hd}{\sqrt{25 - h^2}} + \dfrac{25 g d^2}{2 v_0 (25 - h^2)} \end{cases} \quad (7)$$

From formula (7), we can compute out that the maximum backfill distance is 3.2 meters and the velocity at this point is 7.14m/s, when $v_0 = 5m/s$, $\theta = 0°$, $h = 1.3m$. Thus, the result can meet the backfilling demand in goaf.

5. Engineering practice

5.1. Mining technic condition of testing working face

7204 mining face of Mine is the test face, which belongs to coal seam of monocline structure, whose thickness and obliquity is respectively 0.8~2.5m (1.86m average thickness) and 11°~14°. There are 17 faults in the face, the largest fall is 4.7m, the least fall 0.1m, and the average fall 1.5m. Strike length of the mining face is 570~663m, the dip length is 50~138m, and the covered depth 790m. On the top of the coal seam is composite roof, the thickness of the immediate roof is 1.7~4.0m (2.0m average thickness), and the thickness of the main roof is 0~10.74m (8.0m average thickness). The condition of roof and floor of 7204 mining face is shown in Table 1.

Table 1. Lithology of roof and floor in the working face

Pillar	Thickness (m)	Name and description of strata
	0 ~ 10.74 / 8.0	Fine sandstone. Cemented compactly by mud, relaxative sinuate continuous bedding
	1.7 ~ 4.0 / 2.0	Gray black Siltstone. Cemented compactly, containing a part of the No.2 coal seam at middle part of the east
	0.8 ~ 2.5 / 1.86	The No.2 coal seam. black, containing seldom ash, sulfur and phosphor
	0.7 ~ 1.95 / 1.1	Gray black Siltstone. Richly containing phytofossil, Cemented by calcium, hardly
	0 ~ 10.3 / 8.3	White fine sandstone. Cemented compactly by mud, interlaced bedding

5.2. Preferences of backfilling equipment

Waste packing unit was formed with waste belt, electromotor, support, etc. Based on the test results, Waste packing unit, whose transporting rate was 5m/s, whose length of belt presented V shape was 4.5m, and whose throwing distance was 4m, had been confirmed. Technical parameter was as follows: 500mm belt width, 7.5kW power of electromotor, 4~6m/s belt rate, 1.0~1.5m support height. Backfilling technology was shown in Fig.6.

Fig. 6. Backfilling technology underground

5.3. Application effects of secerning mining and transporting technology

(1) Some costs, including the labor costs, electric costs, upkeep and transporting costs, etc, had been reduced, because original waste was reduced, and was not transported from assistant shaft. The total decreasing cost was 929,500RMB, which was consisted of 450,000RMB labor cost, 365,000RMB electric cost, and 114,500RMB upkeep cost on auxiliary shaft and waste dump.

(2) As the coal quality was enhanced greatly, the ash in the raw coal was reduced by 3 percentage points, and the coal price was elevated by 16 RMB.

(3) According to the related document, environmental charge of the waste was 5 RMB per tonand waste tax was 2 RMB per ton. The environmental charge of 980,000 had been canceled because there was 140, 000 ton waste decreased.

(4) Surrounding environment of the diggings has been improved obviously because of waste being removed.

(5) Some problems about assistant transportation of the mine were settled.

6. Conclusion

(1) Test shows that the secerning mining and transporting and waste backfilling technology, which was put forward firstly, can not only enhance coal quality and real capability of Main Shaft, but also backfill the separated waste in gob.

(2) Separation technology of waste in coal flow，which was developed to enhance coal quality, can effectively control the waste content in raw coal and reduce the burden of coal washing yard, and even cancel the coal washing yard.

(3) By the key to achieving the secerning mining and transporting and waste backfilling technology, waste packing unit was formed with waste belt, electromotor, support, etc. From the practice results, when transporting rate of waste packing unit was 5m/s, and the length of belt was 4.5m, presenting V shape, and the better technical effect should be obtained.

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