Technology and Application Of laneway Strip Filling Mining

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Abstract: In view of the high cost of back-filling mining in coal mine, the production capacity and filling capacity are not balanced, and the filling operation space is limited, the paper proposed roadway strip type filling mining technology, and discussed the principle of roadway strip filling mining technology, introduced the ventilation method, typical equipment matching, technical advantages, etc. And the paper further introduces the example of coal mining under buildings by using roadway strip filling mining technology in Cha hasu coal mine.

1. Introduction
Filling mining is one of the main contents of the coal mine's green filling mining technology system\(^1\). Filling mining has little disturbance to the rock strata and has the effect of controlling the movement of the rock strata and the surface subsidence. It is the most effective way to solve the environmental problems of coal mining and mining under buildings, under railways, under water and over confined aquifers. In recent decades, the promotion and application of backfill mining in metal mines has made considerable progress, but there has not been a large-scale promotion and application in coal mines. In response to the problem of gangue disposal, the state requires all major coal mines to realize the comprehensive utilization of gangue and harmless return to the well for filling and disposal. The state has issued a number of policies to encourage coal mine filling and mining, but the overall progress of coal mine filling and mining has been slow.

2. Laneway layout and mining technology
In order to further improve the mining efficiency of the working face, two working faces are generally used as a mining unit, with a transportation laneway in the middle, a return air laneway on both sides, a mining laneway between the transportation laneway and the return air laneway, and a belt in the transportation laneway, and the filling pipeline is arranged in the return air laneway. The excavation and support operations of the two working faces are carried out at the same time, thus completing an operation cycle\(^2\). After the end of a working cycle, the working procedures of the two working faces are exchanged, the original tunneling face begins to support, and the original support face begins to tunnel.

After an excavation laneway is tunneled through, the filling pipeline is hung in the laneway, and a filling template is installed at the entrance of the laneway to start the laneway filling operation. The filling process and the laneway support process are distributed in different laneway spaces. The operators operate in parallel without affecting each other, effectively solving the problem of mutual restriction between filling and mining.

2.1. CM machine mining technology
The working face is equipped with 1 continuous coal mining machine (EML340) and 1 six arm bolter drill rig (CMM6-20), which work at two heads respectively. The continuous coal mining machine
carries out the tunneling and extracts coal, and the bolt drilling vehicle for roadway support operation. After completing a work cycle, the continuous coal mining machine and the bolter rig are withdrawn separately, the two exchange positions, and the continuous coal winning machine is used to excavate the coal from the roadway that has just been supported, the anchor rod rig is used to support the roadway that has just been excavated. Tunneling and support are crossed and operated in parallel, and the short-distance coal transportation in the mining lane is transported by shuttle trucks and scrapers\(^3\). The mining process and equipment layout of the working face are shown in Figure 1.

![Diagram](image)

1. Shuttle car; 2. roof bolt; 3. form plate; 4. convey belt; 5. crushing loader; 6. continuous shearer; 7. forklift truck; 8. filling line;

Fig. 1. Layout plan of continuous shearer in backfill mining face

The supporting equipment of the working face is shown in Table 1.

**Technical features:**

This technology can give full play to the characteristics of the continuous coal mining machine with fast coal output and high supporting efficiency of the bolter drill carriage. But the machine needs to be moved back and forth during the construction process, which has higher requirements on the reliability of the equipment and the conditions of the roof and floor. This technology is suitable for coal seams with moderately stable roof conditions, and the unsupported part of the roof can reach more than 6m, otherwise the machine will move frequently, which will affect the efficiency of the equipment.

**Table 1 Supporting table of working face equipment**

| No. | Equipment name               | Specification model   | Quantity | Remarks                                      |
|-----|------------------------------|-----------------------|----------|----------------------------------------------|
| 1   | Continuous shearer           | EML340                | 1        | Complete coal cutting, coal loading and roof bolting. |
| 2   | Shuttle car                  | SC15/182F             | 1        | Complete coal short distance rapid transportation.  |
| 3   | Feed crushing and transferring machine | PZL460/150B | 1 | It is used with shuttle car to complete transportation buffer and crushing. |
| 4   | Six arm bolter drill rig     | CMM6-30               | 1        | Complete the top bolt and side bolt supporting.   |
| 5   | Scraper                      | ZL20EFB               | 1        | Complete floating coal cleaning and material handling. |
2.2. Ventilation system

The working face ventilation adopts a combination of full air pressure ventilation and local fan press-in ventilation. Local fans are installed in the main transportation laneway. Local fans are used for ventilation before the mining laneway is penetrated. The fresh air flows from the air duct of the main transportation laneway in the middle to the mining laneways on the two wings. The fresh air flows from the air duct of the main transportation lane in the middle to the mining lanes on the two wings. After the coal mining roadway is connected, the ventilation facilities such as wind barrier and air curtain should be set in time, and the air path should be adjusted to avoid blind roadway. After the alleys are opened, wind barriers and curtains shall be installed in time to adjust the air routes to avoid blind alleys. During the filling process of the mining laneway, the ventilation method adopts the full negative pressure ventilation method. Ventilation windows are left when the formwork is installed at the openings at both ends of the mining laneway. Fresh air flow enters the filling and mining laneway from the air window along the transportation laneway, and at the same time, the fresh air flows into the return air laneway from the side window of the return air laneway. The working face ventilation
system is shown in Figure 6.

![Diagram of Working Face Ventilation System](image)

1. Roof bolter; 2. form plate; 3. paste; 4. regulating wind barrier; 5. fan; 6. wind belt; 7.CM; 8. Filling line

Fig. 6. Working face ventilation system diagram

3. Technical advantages of full mining and full charging in lane strips

The filling space is simple to close, the filling rate is high, and the surface subsidence is small. In the paste filling process behind the long-wall fully mechanized mining frame, in order to construct a closed filling space, the bag is usually hung in the filling area behind the support (called "bag filling"). Or lay geotextile behind the support of the whole working face to construct the filling space. However, this method has the problems of heavy workload, and low top connection rate. While the strip filling working face of the roadway uses the strip mining house as the filling unit, only the two ends of the mining laneway need to be closed, the workload is small, and the operation is simple. During the filling process, the filling pipeline is arranged on the roof of the roadway. The slurry is extruded from the top plate by pipeline pressure. This method can greatly improve the filling rate of working face and reduce the roof subsidence and surface subsidence to the greatest extent.

Low filling cost. In the lane strip filling process, the first-step filling uses high-strength paste filling, and the second-step filling uses low-strength paste or raw gangue filling. This combination of strong and weak filling filling technology greatly reduces the direct material for filling and mining. At the same time, due to the simple sealing process, auxiliary materials such as filling bags and geotextiles are also saved, and the cost of filling auxiliary materials is reduced.

4. Application examples

4.1. Overview of resource conditions

In order to realize the effective disposal of gangue, the Chahasu Coal Mine of State Grid Construction Investment Inner Mongolia Energy Co, Ltd. has carried out the practice of coal mining under the building by adopting the technology of strip filling mining.

The filling mining area of Chahasu Coal Mine is located in the north wing of the 31st mining area. The area is located in the north side of the development laneway on the east wing of the first level, above which there is a ring railway loading station built by the mine. Six filling working faces are initially planned in this area, and two filling working faces 301 and 302 are mined in the first phase. The coal seam thickness of the working face is 4.50~5.45m, the average thickness is 4.95m, and the inclination angle is 1°~3°. The coal seam structure is relatively simple. The basic roof of the coal seam is medium-grained sandstone and sandy mudstone with a thickness of 6.5m to 13.2m. The direct roof is made of mudstone and sandy mudstone with a thickness of 2.75m to 3.5m. Some areas contain false roofs, which generally do not exceed 0.5m in thickness. Take the risk. The direct bottom of the
coal seam is carbonaceous mudstone and sandy mudstone, with a thickness of 0.75m to 2.15m.

4.2. Technical scheme of mining face filling and mining
The overall mining technology scheme of the working face adopts the lane strip mining technology. The length of the working face along the trench is 500m, the length of the mining lane is 50m, and the width of the mining lane is 5m. There are 192 mining lanes arranged in the two filling working faces.

Fig. 7. Layout of the filling mining area and navigation channel

The working face adopts the "mining one leaving one" interval skip mining technology, and the mining and filling processes are carried out in the following two steps:

The first step: adopting two excavators (EBZ200C) and anti-explosive scrapers in accordance with the "mining one leave one" interval skip mining technology, and carry out strip mining of solid coal from the side of the return air laneway to the side of the transportation laneway. After mining, the room is filled with high strength gangue gypsum;

The second step: After the first step of stopping strip filling is completed, and the filling body in the roadway reaches the predetermined strength, the machine Integrated with Mining and Excavation (EBZ200C) and the explosion-proof scraper are used to recover the spaced coal pillars between the filling body. After each coal pillar is mined, filling with low strength gangue gypsum.

Through this process step, complete the whole 301 and 302 working face mining work.

4.3. On-site production of working face
The project began underground construction in September 2019, and at the same time began construction of the surface filling station. The filling station construction was completed in early December 2019, and commissioning and joint trial operation began. The joint trial operation was successful on December 25;

Affected by COVID-19, the work face was suspended from January to March 2020, and production began to resume in April. After nearly 8 months of intense and busy site production, the project was successfully completed at the end of December 2020 The filling and mining tasks of the two working faces 301 and 302 have produced 340,000 tons of coal and filled 230,000 m$^3$;

During the mining period, the highest monthly production record was created with the highest monthly footage of 1626m, 54145 ton coal output, and 32452m$^3$ filling.

The contact effect between the filling column and the roof is good. Through the observation of the surface subsidence point in the past year, the horizontal deformation $\varepsilon \leq 2$mm/m, and the vertical deformation $i \leq 3$mm/m. Figure 11 and Figure 12 show the situation of on-site roof connection and replacement mining of the working face.
Fig. 8. Top connection situation of filling body in working face

5. Conclusion
The tunnel strip mining and full filling technology is a successful filling mining technology, which has become mature and perfect after continuous development in recent years. This technology can be widely used in "three under" pressed coal and corner coal mining, and can also be used in gangue solid waste disposal. It has been successfully applied in Inner Mongolia, Shanxi, Shaanxi and other mining areas, and has achieved huge economic and social benefits. The promotion of this technology has broad market prospects.

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