The Application of Speedy Drivage System in Daliuta Coal Mine

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Abstract: In order to solve the problem of continuous tension in production from low driving efficiency of coal mine and excessive mining, Daliuta coal mine put forward the idea of using the rapid drivage system for roadway tunneling innovatively. The system optimized the excavation process and used remote control to alpine bolter miner to cut coal. It used straddle type anchor to support the roof and used belt reloader to carry coal. The parallel operation of digging and supporting and one time forming of top support is realized. Thus, the safety of operation and drivage efficiency are greatly improved. It is effective to relieve the difficulty of the tension of coal mines. It came up a lot of problems in the application process of speedy drivage system. But through continuous optimization and improvement, the advantages of speedy drivage system get better play. Since the speedy drivage system used in Daliuta coal mine, it created world’s record of the maximum daily footage of 102m, the maximum monthly footage of 2514m, per capita ergonomics reached 1.33m/capita.

1. Introduction

The development of fully mechanized mining technology makes the recovery speed of fully mechanized mining greatly improved. As a result, the contradiction of disproportion of mining and excavation is becoming more and more prominent. Production succession is increasingly tense. This has become a prominent problem that restricts the increase of production and expansion of mines. Therefore, the development of speedy drivage system adapted to safe and efficient fully mechanized mining has become the key to solve this contradiction. Speedy drivage can be divided into two types. One is the excavating and anchoring unit with the integration of excavating and anchoring. In the developed countries in 1990s, the excavating and anchoring units of speedy drivage and bolt support were developed. The equipment has achieved good results in Britain, Australia and the other countries in large section coal roadway driving middle-aged footage as high as 15000-20000m. The other is to use the continuous shearer and anchor machine to cross the transposition, and more used in the roadway layout of the working face. Shenhua Shendong Coal Group Co. Ltd combined the special geological conditions of its own mines, broke through the tradition and innovating boldly, and began to explore the high efficiency speedy drivage system. This system used an operation mode of bolting machine to cut coal, straddle type anchor to support, belt conveyer to transport coal. It realized the integration of excavating, supporting and transporting. And also simplifies the link of equipment adjustment, optimized the transportation system and improved the driving efficiency. The speedy drivage system and back-up equipment were installed in Daliuta coal mine in January 25th, 2013. It started production in February 6th. It has created the world record of large section single lane tunneling.
Speedy drivage accumulated tunneling 15448m, the maximum daily footage of 102m, the highest monthly footage of 2514m by the end of April 20th, 2014.

2. Composition and application of speedy drivage system

2.1. Composition of speedy drivage system

The speedy drivage system is mainly composed of MB670 bolter-miner, LY2000/980-10 crusher, CMM8-30 eight arm anchor drill, KP00 adaptive belt conveyor, KL00 craw-type self-moving tail, KM100 stepping self-moving tail, DSJ-100/100 belt conveyor and other equipment. The composition of the equipment is shown in figure 1. Each equipment is arranged in the laneway in sequence. The main technical parameters of each equipment are shown in table 1.

![Speedy drivage equipment layout map](image)

Table 1. Main technical parameters of each equipment in speedy drivage working face

| Equipment Type               | Outer ruler inch (length × width × height) | Mining height | Truncated head width | Cutting head width | Coal mining capacity |
|------------------------------|--------------------------------------------|---------------|----------------------|-------------------|---------------------|
| MB670 Bolter-miner           | 11200×5000×3200mm                          | 3200-4500mm   | 6000mm               | 25T/min           |
| LY2000/980-10 crusher        | 10098×3140×2187mm                          | 2000t/h       | 2000t/h              | 300kw             |
| Straddle Type eight arm anchor drill | 9600×4000×3000 mm                   | Adaptive roadway height | Number of drill arms | Support time(minimum m) |
| Adaptive belt conveyor     | Tape size (length × width)                | ≥1600t/h      | Gap from the ground  | ≤6º               |
| Stepping self-moving tail   | Adaptive roadway height                   |               | Top beam pair        | Base to floor pressure |
| Craw-type self-moving tail  | Outer ruler inch (length × width × height) | 3500-4500mm   | Adapt to the minimum height of the roadway | 2Mpa               |

The coal cut by bolter-miner is broken through the crusher and transshipped to the crossheading belt through an adaptive belt conveyor. Straddle type anchor with bolter-miner complete the roof.
bolting at the same time. The adaptive belt conveyor keeps up with the excavation of the bolter-miner to move forward by a crusher. To implement continuous operation. The end of belt conveyor through Stepping self-moving tail to accomplish self-moving function. The continuity of the conveyor and the crossheading belt is guaranteed. In this way, the mechanized construction method of parallel operation of breaking, transporting, loading and supporting process is carried out alternately.

2.2. Running course of speedy drivage system

The application of speedy drivage system can be divided into 3 stages in our coal mine.

1. The first stage (Preliminary successful application)

The first speedy drivage system and supporting equipment are installed in 52305 haulage roadway installation of the company’s Daliuta coal mine in January 25th, 2013. Formal production in February 6th, 2013. The 52305 haul road in Daliuta coal mine was completed in April 9th. It has completed footage of 2250m. It has completed 1500m per month in March, maximum daily footage of 68m, class maximum length 46m. Speedy drivage system application had a preliminary success.

2. The second stage (Continuous improvement, significant improvement in tunneling efficiency)

The new system also exposed a lot of problems in the operation. The system is short of broken system, block phenomenon often occurs in the transportation process. There are too many coal wasted in the transfer point of the shovel board of bolter-miner and belt conveyor. Bad effect of dust removal by ventilation and so on. Through the unremitting efforts of Shendong company’s leaders and colleagues. The improved system was put into use in the 52307 haulage roadway of Daliuta coal mine in February 10th, 2014, finished tunneling of the roadway in April 20th, and completed footage of 4464m. Speedy drivage system rose from 36m to 65m average daily footage, the highest daily footage is 102m; the highest footage is 2514m per month. It created a world record in a large section of the coal roadway by single tunneling.

Up to April 20th, 2014, the cumulative tunneling 15448m of the speedy drivage system, the coal consumption is 502 thousand tons; the highest footage is 2514m per month. The speedy drivage system has completed 52305 haulage roadway, 52302 haulage roadway, 52301 ventilation roadway and 52307 haulage roadway in Daliuta coal mine. It eased the production continuity and laid the foundation for increasing production and expanding capacity.

3. The third stage (Improved second sets of speedy drivage system)

The second speedy system is based on the original system mode, reformed and innovated tunneling speed, supporting efficiency and transportation mode; To achieve the best configuration of tunneling, support and transportation to the greatest extent possible and to achieve the purpose of reducing the cost and increasing efficiency. The system is expected to be put into use in Daliuta coal mine 52501 ventilation roadway on July 2014. The second system is mainly composed of QMJ4260 TBM, crushing elevating conveyor, CMM10-30 ten arm anchor drill, flexible tape elevating conveyor and buckstay of stepping self-moving tail etc. equipment. Compared with the first system, the system has been improved mainly in the following areas:

1. The bolter-miner to replace the TBM

Compare with the bolter-miner, TBM has the following advantages: 1) TBM is faster, the maximum speed is 0.2m/min; 2) TBM has self-contained dust removal system. The system includes internal, external spray and two dedusting fans; airflow is 500m³/min, dust removal effect is enhanced. 3) Installation of protective ceiling over body, roof with electro-hydraulic control, adjust the position of the ceiling according to the requirement and ensure the safety of the overhaul staff without the need of returning the machine.

2. Improvement of roof bolter

The roof support of roadway is completed by ten arm anchor drill: 1) 4 sets of top drill arms are arranged at the front of the fuselage, 2 sets of top drill arm centered arrangement, the other 4 sets of arm reduplication in the back row, 2 on each side, 10 sets of drill arms can work simultaneously, greatly increase the speed of support. 2) The dust-removing duct is integrated into the Anchor body, which reduces the width of the fuselage and facilitates the equipment to walk. The ten arm anchor drill
can change the restriction of the supporting operation on the tunneling speed and improve the tunneling efficiency.

3. Improvement of arranging flexible tape elevating conveyor and stepping self-moving telescopic sealing-tape machine

Overlapping arrangement of the tail of the stepping self-moving telescopic sealing-tape machine and the flexible tape elevating conveyor. (Shown in Fig. 2) Adopt crushing elevating conveyor and stepping self-moving telescopic sealing-tape machine to complete coal crushing, transportation and reprint. 1) After overlapping arrangement of the tail of the stepping self-moving telescopic sealing-tape machine and the flexible tape elevating conveyor. Reducing the requirement of roadway width, the pedestrian side width of roadway is 2.3 m, which is convenient for auxiliary transportation. 2) The effective length of reprinted belt overlap section is increased to 100m, which created conditions for further increasing production and improving efficiency. 3) Combined craping crusher and flexible tape elevating conveyor. The shovel plate of the crusher had the function of moving in situ, which was convenient for the crusher to clean up the floating coal near the side and reduced the labor intensity of the workers. The loading part of the flexible tape elevating conveyor is connected with the chassis of the crusher through a hinged rotary table. The operation can automatically adjust the loader’s loading section by leveling the oil cylinder and the tilt angle sensor to keep the drum level and prevent the belt from running off.

3. The applicable geographic condition for rapid development system

The rapid development system can be applied under the following conditions, thick coal seam, stable roof and floor, coal seam dip angle is below 3°, 6.0m width and 4.2m to 4.5m height of cross section. The rapid development will be realized when the development work is done along the roadway floor. For example, the geographic conditions of Da Liu Ta No.52307 haulage gate development working face are as follows.

3.1. The status of coal seam and surrounding rocks

The thickness of coal seam in development area is 7.54 to 7.7m, the stable coal seam thickness is 7.6m on average, and there are 1 to 2 layers of dirt band embedded at the bottom of coal seam with the thickness of 0.05 to 0.15m, the coal seam structure is relatively simple, the dirt band and the immediate roof is mainly mudstone, and the immediate floor is mainly mudstone and siltstone.

3.2. Geologic structure

The bedrock thickness of this working face is 100 to 180m with the overall gently monoclinic coal seam structure; some part of the coal seam is widely and gently undulating, the elevation of coal seam is 994.5～1012.5m, slope development is mainly recommended.

4. Development Process and construction organization

4.1. Construction design

1.Cross section of heading

According to the development technical requirements of 7 m high face mining, the development cross section of the roadway should be 6.0×4.2m (width×height)

2.Roadway support design

The roof should be supported by general anchor bolt and wire mesh, there will be 6 general anchor bolt in one row with the 1.0×1.2m distant between each row, 3.0m wire mesh should be put up on the lower wall, 2.6m wire mesh should be put up against the roof and 0.4m wire mesh should be against the wall.

The higher wall of the roadway should be supported by FRP Bolt and plastic wire mesh. There will be 2 bolts in one row with the 1.0×1.2m distant between each row. The lower wall of the roadway should be supported by rod bolts and wire mesh, there will be 2 bolts in one row with the 1.0×1.2m distant between each row.
4.2. Development Process

1. Coal-dropping, Bolter-Miner driver use the remote control in the rock bolt drill vehicle driving cab to carry out coal-dropping process via Video image remote operation.

2. Coal-charging, Bolter-Miner auto coal charging is applied, the Bolter-Miner is equipped with collecting head and middle conveyor, when Bolter-Miner is cutting the coal seam, coal will drop into the collecting head, and rake claw loading mechanism is continuously feeding the coal into middle conveyor and middle conveyor will convey the coal to the receiving hopper of conveying vehicle at the back of the Bolter-Miner.

3. Coal transportation, the coal will be transported to adaptive belt re-loader to belt conveyer after being crushed by receiving hopper of conveying vehicle to complete the process of continuous coal transportation. The falling coal will be loaded by Bolter-Miner through conveying vehicle to adaptive belt re-loader, and then the coal will be transported to channel belt machine to complete the transportation process.

4. Roadway shoring, 10 sets of general anchor bolt and wire mesh shall be applied to the roof by a straddled, eight-arm anchor drill. 4 drill arms in front of the roof bolter will support the roof with 6 set of general anchor bolts, 2 of the associated drill arms will support the side wall of the roadway with 2 set of general anchor bolts for each side.

4.3. Construction organization for rapid development system

1. Work shifts
   
   For roadway development work, there should be three eight-hour shifts per working day, the first two eight-hour work shifts will start from 00:00 and 04:00 am respectively for roadway development, the last eight-hour shift will start from 08:00 am for maintenance.

2. Construction organization
   
   (1) Maintenance team responsibility

   Maintenance team is fully in charge of equipment maintenance and production preparation work, Maintenance team also manages the extension and storage of the belt conveyer, the water and power supply, the stock and transportation of supporting materials, auxiliary production materials, such as fan stack, power cable and water pipes, etc.

   (2) The main working procedure circulation for production team (Yuan Team 94m)

   The main working procedure circulation is as follows, production preparation and safety inspection → 94m roadway development → 94m roadway support and fan stack extension.

5. The advantages of speedy drivage system

1. The equipment layout is more optimized and the safety is greatly improved.

   Compared with the traditional continuous mining, the rapid tunneling system eliminates the moving equipment such as a continuous coal mining machine, a shuttle car and a forklift and the like, thereby not only saving the adjusting time, but also eliminating the potential safety hazard caused by the moving equipment in the roadway.

2. Video supervision, remote operation

   An innovative approach to the operation of a road header from a traditional close-to-eye, hand operation – to – remote video monitoring, remote control operation. In order to be able to monitor the operation of the tunneling machine in real time, avoid personnel working under the air roof. The heading machine drivers only need to sit on eight arm anchor drill, the remote control of the heading machine is controlled by remote control by the video server and the working face data provided by the computer. As a result, not only the potential safety hazard of the operation of the driver of the heading machine and the direct contact with the dust are effectively eliminated, but also the coal is directly guided by the data, so that the accuracy of the cutting coal is improved, and the engineering quality is ensured.

3. Quick–support, quick–digging, to realize excavation, support parallel operations
Speedy drivage system matched straddle type eight arm anchor drill. The machine is equipped with 8 booms. Respectively, 4 former anchor drilling arms, 2 after the anchor arms, 2 side anchor drilling arms. Three rows of arrangement in front and back. The vehicle ridded on adaptive belt conveyor. During the production process, the straddle type eight arm anchor drill rod machine can move forwards and backwards to complete the support of the top plate and the roadway side.

4. Efficient continuous transportation

The coal dropped by the bolter-miner is crushed by the crusher and loaded into the adaptive belt conveyor, and the coal is transferred to the belt conveyor in the transport lane by the unloading unit, which realized the continuous transportation of the driving face.

5. The ventilation system is optimized and the working environment is improved.

Although the traditional entry ventilation method of single roadway can meet the needs of wind supply, it is easy to cause coal dust pollution along the belt and the working face, which is not conducive to the health of employees [9]. According to the field condition, the working face is ventilated by long pressure and short ventilation, and a suction type dust removal fan is installed, and the local ventilation fan is used to supply the wind. The dust concentration of the working face is reduced by at the same time [10].

After careful calculation, continuous test and renovation, it is determined that the pressure-type soft tuyere is suspended from the top of the non-pedestrian side roadway of the belt. An outlet from a straddle type eight arm anchor drill tail is not greater than 10m. The extractable wet dust collector is installed on the frame of the belt conveyor, which is fixed on the front end of the bolt machine and moves forward with the tunnel heading. It not only ensures the normal air supply in the working face, but also can deal with the dust on the spot, reduces the dust concentration in the working face, and greatly improves the working environment of the workers.

According to the underground field measurement, using the ventilation scheme, the dust concentration of the whole dust in the straddle type anchor drill working face during production is reduced from 134.8mg/m³ to 41.86mg/m³. The dust mass concentration is reduced from 26.2mg/m³ to 6.64mg/m³.

6. Optimization of staffing and improvement of production efficiency

Compared with the traditional company excavating system, the rapid tunneling system has more equipment and more staff. In order to reduce the number of fast tunneling operation and improve the working efficiency of the speedy drivage system, According to the running status of the system, the personnel of the belt post workers, the anchor driver and the belt reloader are optimized. After the operators are reasonably optimized, the number of operation personnel per shift is reduced by 3 persons, the tunneling work efficiency reached 1.33m/capita, and the work efficiency is obviously improved compared with the traditional mining excavation (work efficiency is 0.7 m/capita - 0.9 m/capita).

6. Conclusion

Through the test and the application of the speedy drivage system in Daliuta coal mine, the integrated operation of tunneling, support and transportation in the production process is realized, the adjustment time caused by the separation of the original excavation and support is reduced, the opening probability of the equipment is increased, and the tunneling efficiency is improved. The efficiency and safety of the speedy drivage system are obviously reflected. And through continuous improvement, speedy drivage system refresh record footage constantly, The application of speedy drivage system will further alleviate the contradiction of mining, promote the balance of mining, and further promote the high yield and high efficiency of mine.

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