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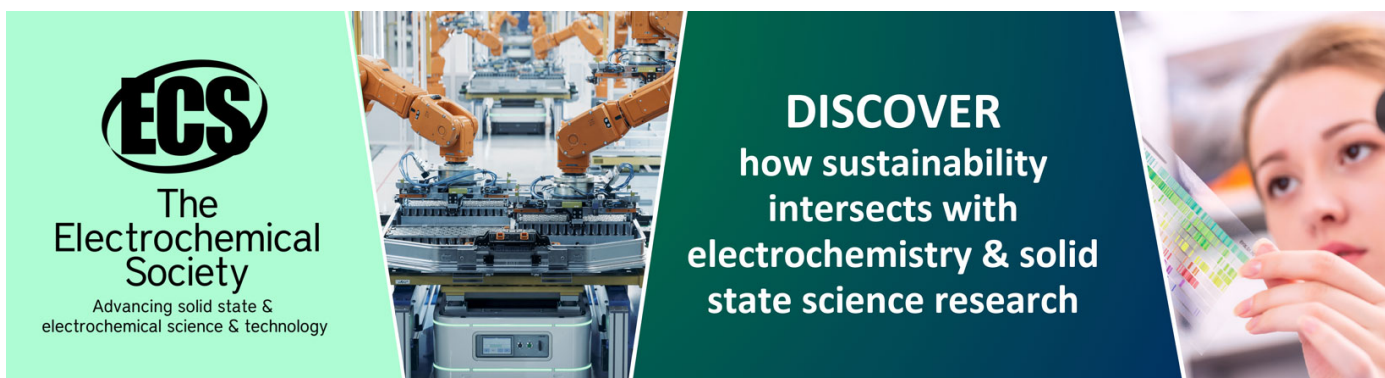
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Analysis on Key Problems of Winter Operation in Alpine-cold Open-pit Mine

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Abstract: Through the analysis of winter operation problems in the alpine-cold open pit mine in Mengdong area, the technical and economic feasibility of adopting advanced peeling and winter peeling scheme is demonstrated. For the open-pit mining and transportation equipment in the alpine-cold region, the solutions for the scooping and sticking materials, the freezing of the brake circuit, and the sticking of the compartments are often proposed in winter operations. The anti-freeze system of the belt conveyor is composed of the cold resistant tape, the cleaning device, the antifreeze film, the heating device and the anti-freeze roller. Some safety production organization measures for blasting operations, mining operations, and semi-continuous systems in winter construction operations were proposed. It can effectively help the open pit mines in the alpine-cold regions to reduce equipment failures and ensure efficient operation in winter safety production.

Key words: alpine-cold open-pit mine; electric shovel; belt conveyor; safety production measures.

1. Introduction

The northeastern region is an area where open-pit mines are concentrated, especially in the eastern area of Inner Mongolia (called as the Mengdong area). Lots of representative large open pit mines such as Baorixile Open-pit Mine, Yimin Open-pit Mine, Shenbei Shengli Open-pit Mine, and Baiyinhua Open-pit Mine are built. These mining areas are temperate monsoon climate or temperate continental climate. The winter is cold and long. The temperature difference is very big every day. The open pit mines in Mengdong area are representative of the open-pit mines in the alpine-cold region.

The main production is lignite in the Mengdong area, the overlying loess and rock and the coal produced are high moisture content, combined with the cold weather and the humid environment, the large-scale loading and transportation equipment often failure and freezes. It has seriously affected the progress of normal production operations of open pit mines, resulting low efficiency and insufficient coal supply in winter. This paper summarizes some measures adopted during the winter in the large open pit mine in Mengdong area, and hopes to effectively solve the winter operation problem of open pit mines in alpine-cold regions.



2. Advance peeling, winter stop peeling

Both the Huaneng Yimin Open-pit Mine and the Shenhua Baorixile Open-pit Mine adopt mining policies for advanced peeling in summer and autumn to reduce the operational impact of cold weather. Advance peeling is beneficial to reduce equipment loss, reduce the amount of blasting work, and reduce the operating time under high consumption and low output. In fact, winter work will seriously affect the efficiency of equipment operation, resulting in a large deviation between the planned output of production operations and the actual output. The 2017 original coal production planned output and actual output, the mining operation planned output and the actual output of the Yimin open pit mine are plotted with a matlab and the high-order fitting analysis of the curve is performed, as shown in Fig. 1.

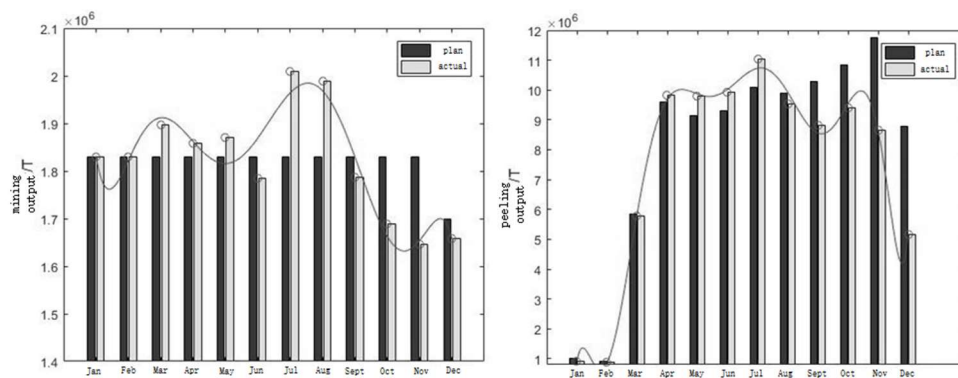


Fig.1 The mining operation planned output and the actual output of Yimin open pit mine in 2017

It can be seen from the figure that due to the influence of the winter working environment, the output of raw coal of the Yimin open-pit mine in the winter operation (January-March, October-December) is low, even if the winter planned operation is much lower than the output planned in the summer, the actual output is still much lower than the planned output. In terms of raw coal production, the large-scale open-pit mine in Mengdong area is the main coal supply base in the northeast and central areas. Therefore, the demand for coal in winter is large, but it can be seen from the figure that the actual output of raw coal is much lower than the actual planned output. This phenomenon is particularly evident in October and November. In terms of peeling operation, due to the cold weather in Mengdong, the equipment fault is increased, the equipment failure rate is increased, the employee's working environment is bad, and the blasting workload is increased. The actual output of the peeling operation is much lower than the planned output, which is particularly noticeable when the temperature drops suddenly in November.

The Yimin open pit mine has implemented a winter stop peeling scheme in a technically feasible and economically situation. The implementation of the program requires the following conditions: (1) to improve the flat relationship, to supplement the amount of coal that can be mined and to exploit coal. If the two-month winter peeling plan is implemented, it is necessary to gradually improve the flat-panel relationship in the production process through technical means. Before the implementation of the peeling, the recoverable coal can be replenished to the recoverable period for more than two months. Exploiting coal volume increased to 4 months; (2) adopting the method of advanced peeling to supplement the exploit coal that can be mined in winter, Generally take the way to increase the amount of outsourcing; (3) the implementation of the winter peeling scheme is not completely stopping, but is drastically reduced. For example, the planned peeling amount of the Yimin open-pit mine in November 2017 was 1.175 million m^3 , and in December it was 8.8 million m^3 . The planned peeling amount in January was 1 million m^3 , and in February, the peeling amount was 0.9 million m^3 . Winter stop peeling means that the amount of work during peeling is much smaller than the usual amount of peeling. From the perspective of practical production results, adopting the winter stop peeling scheme is beneficial to the operation, management and benefits of the large-scale open pit mine. It can have obvious effect by improving the flat relationship by means of advanced peeling.

3. Winter equipment problems and solutions for mining equipment

3.1. *Material sticking of electric shovel bucket*

In the winter operation, the electric shovel has a serious problem of material sticking. In the winter extreme temperature, the amount of material with high water content can reach half of the volume of the bucket, which has a serious impact on the efficiency of the shovel and the ratio of the shovel and cat.

At present, there are several measures to alleviate the material sticking. (1) Using the mechanical scraper method to increase the volume utilization rate of the electric shovel bucket, (2) Some mines in order to reduce the sticking phenomenon of the electric shovel bucket, put a layer of anti-mucosa on the inner wall of the electric shovel bucket. (3) From the perspective of excavating materials, it is most likely to cause the bucket material to be peeled off by removing the loess material. Therefore, the operation plan of advanced peeling and winter peeling is adopted, and the loess is not peeled off as much as possible. If the mine has plans to carry out the peeling operation in the winter, it can selectively and continuously peel the two adjacent soft rock flats above the coal seam. Since the freezing process of the flat surface of the soft rock face in winter is gradually frozen from top to bottom, it takes a certain time for the working surface to be completely frozen after exposure. Therefore, the flat surface of the peeling work surface is not exposed for a long time, and the material is not frozen. The electric shovel of the two adjacent soft rock flat plates above the coal seam can be continuously operated to reduce the exposure time of the material on the peeling working surface, which can effectively reduce the shovel bucket glue [2]. This method is suitable for alpine-cold open pit mines with a temperature of minus 20 degrees Celsius in winter. If the temperature of the Shenglidong No. 2 mine is higher than minus 20 degrees Celsius, it is best to carry out the second peeling within 1 month after the exposed working face exposure time. As the temperature decreases, the shorter time interval for secondary peeling, the optimum time for secondary peeling between minus 20 degrees Celsius and minus 30 degrees Celsius is about 15 days. Therefore, for the high-altitude open pit mines that have been at a temperature of minus 30 degrees in the winter, such as the Yimin open pit mine and the Baorixiler open pit mine, they should be used as appropriate.

3.2. *Electric shovel brake circuit freezing*

The electric shovel often freezes the air passage when the brake is applied to the winter pushing mechanism. The cold climate combined with the humid environment, the two factors work together, causing the air compressor inside the shovel to compress the air moisture content is too high [3]. Constantly freezing causes the shutdown to occur frequently, accompanied the brake system of shovel mechanism is continuously worn out, and after the airway is frozen, there will be failures such as dead brake slippage, and the bucket rod is out of control and shot out quickly.

Solution: Install a three-way in the air head of the pushing mechanism in the machine compartment, so that the push brake and the dead brake are separated from each other, and a water separator is installed in the air passage of the through brake. Connect the air duct on the push platform guardrail to install the pressure regulating valve, the main valve, the branch valve, the alcohol inlet hole, the air pressure gauge, and the electric shovel brake circuit freezing solution is shown in Fig.2.

Design effect: (1) Oil-water separator, which mainly separates the water and oil leading to the compressed air of the dead brake. (2) The function of the main road valve and the branch valve is: when the dead brake is frozen, or when adding alcohol to the alcohol pipe, the main valve can be closed, the branch valve is opened, and after the net residual pressure is exhausted, the alcohol is added to the hole. when the branch valve is added to the alcohol, close the branch valve and open the main valve to thaw. This method can effectively solve the problem of air passage freezing.

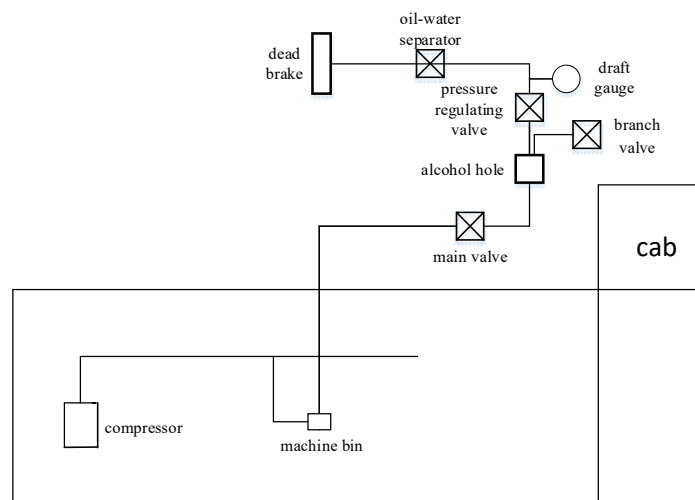


Fig.2 Electric shovel brake circuit freezing solution

3.3. Truck carriage material sticking

In the high-cold open-pit mine, when the truck transports the coal with high water content, the material sticking reaches 1/3 of the volume of the carriage, and the utilization rate of the bucket volume drops sharply. It is necessary to increase the ratio of the shovel and truck. Many large open pit mines use backhoe fixed-point treatment: when the truck finds that the carriage is serious during transportation, it goes to the designated backhoe to clean it and then continues to work, increasing the truck's transportation distance and increasing the cost while greatly reducing the transportation efficiency. A serious waste of production capacity.

This problem can be solved by referencing on the exhaust system of the Belaz trucks in white russia. The exhaust system is shown in Fig 3. The exhaust gas from the disposal system is transported from the turbocharger to the exhaust pipe with the seal through the connecting pipe and the exhaust pipe. The trachea is then discharged along the flue of the dump truck into the flue at the bottom of the truck tank. Heating the bottom of the tank through the exhaust system can effectively solve the problem of truck sticking.

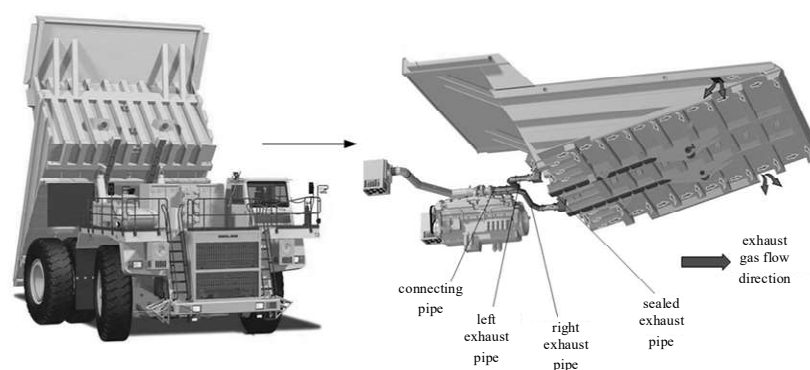


Fig.3 Exhaust system diagram

4. Belt conveyor winter operation problems and solutions

The open-pit coal mine in Mengdong area is affected by its coal-forming geological age. The moisture content of exfoliated materials such as mudstone, carbonaceous mudstone and sandstone and lignite are higher [4], which will lead to the freezing of belt conveyor under severe winter conditions. the failure rate and repair rate of key components are increased, and the belt conveyor is the core transportation

equipment of the semi-continuous transportation system. The system capacity will be greatly reduced during winter operation. The following describes the several cold-proof measures of belt conveyors.

4.1. Cold resistant tape

In equipment selection, belt conveyors should select suitable tapes in combination with local geological and weather conditions. For open-pit mines in alpine-cold areas, tapes with better cold-resistant, non-flammable, tear-resistant and anti-freezing should be selected. According to the chemical industry standard of the People's Republic of China (HG/T 3647-1999), the specifications of cold resistant tape are as follows:

1) Structure: The core of the cold-resistant belt is made of one or more layers of canvas, and the core is covered with a cold-resistant cover rubber and a side glue.

2) The cold-resistant belt is divided into three types according to the performance of the cover layer: the scratch-resistant type (H), the wear-resistant type (D) and the general type (L). According to the cold resistance, it is divided into two grades: C1 and C2. The ambient temperature of C1 is $-45^{\circ}\text{C} \sim +50^{\circ}\text{C}$; the ambient temperature of C2 is $-60^{\circ}\text{C} \sim +50^{\circ}\text{C}$.

Open-pit mines in alpine-cold regions should be resistant to scratch-resistant (H) and C2 grade cold-resistant tapes.

4.2. Cleaning device

At present, the most common way to clean the frozen conveyor material of the belt conveyor is to install a cleaner. Most of the open pit mines use the currently widely used H-type and P-type cleaners to clean the working face of the tape after the machine head has been blanked. At the same time, a double scraper cleaner is installed at the attachment pipe of the machine head for further cleaning. An O-type cleaner and a double-scraper cleaner are added to the head and the tail to clean the non-working surface of the tape.

Many mines have begun to use new cleaners or retrofits for cleaners. For example, Baiyinhua No. 3 open-pit coal mine replaces the square steel sweeper of the drum with a wire cleaner. When the roller paste reaches a certain thickness, the adhesive and the cleaner When the blade is in contact, the roller drives the rotary cleaner to rotate. Because the blade has a spiral angle, the adhesive is cut by rotating the blade to achieve the cleaning effect.

4.3. Tape freezing adhesion

In the winter, the water-containing materials will freeze the belt, causing the belt to return to the belt seriously. At the same time, a large amount of coal is required to be manually removed, which reduces the transportation capacity of the belt and increases the construction cost in winter.

Destroying the formation conditions of the material's frozen adhesive tape from the source, Shenhua Baorixile and Shenbei Shengli Open-pit Mines use a high concentration of multi-formulated calcium chloride aqueous solution to form an antifreeze film between the tape and the material, effectively blocking The frozen and viscous material is in contact with the bearing surface of the conveyor belt, and the freezing and sticking inhibition effect is very obvious. According to the different ambient temperature, the raw material and the additive input amount can be reasonably adjusted, so that the antifreeze liquid can reach the optimal ratio, and the adhesive can be reduced by more than 90% of the coal [5].

4.4. Heating equipment

In the belt conveyor, it is easy to produce frozen parts of the material such as the silo, the hopper chute and the floor of the overflow scraper, which can effectively prevent the material from freezing. The Yimin open-pit mine will install a sealed constant-temperature electric heating device to the side wall of the hopper chute and the floor of the squeegee scraper. The heating power of each heating plate is 1KW, and four heating plates are installed per square meter. Each heating plate is provided with a temperature detecting device, and the heating plate automatically controls the heating within a set

temperature range, and changes the temperature of the heating plate according to the change of the ambient temperature, for example, the ambient temperature in the winter is between 0°C and -20°C. When the temperature of the heating plate is set at 25°C, continuous operation throughout the day, the hopper side wall and the overflow squeegee bottom plate can reach the preset temperature to prevent the occurrence of freezing and sticking phenomenon [6].

4.5. Roller freezing adhesion

When the roller freezes seriously, the material freezes quickly and continuously accumulates, causing the freezing and sticking to become more and more serious, eventually leading to the failure of the cleaner. It can only be shut down and manually cleaned with tools such as sledgehammers and chisels. There is a hidden danger of the scratched conveyor belt, which causes the conveyor belt to be pierced by the adhesive.

Xilinhote Mining Company successfully developed anti-freeze roller using ultra-high molecular weight polyethylene powder near-melting extrusion technology. The self-lubricating, anti-fouling and low-temperature resistance of the anti-freeze roller surface make the slime unable to freeze, so only the slime is frozen together, and the bond strength between the slime is low, when frozen to a certain extent, due to The centrifugal force of the surface of the drum and the extrusion of the conveyor belt, the combination of the frozen materials is destroyed, and the frozen adhesive is separated from the drum. The anti-freeze adhesive roller works well after being put into use[7].

4.6. Belt conveyor anti-freeze system

The belt conveyor is protected against freezing and sticking by arranging cold-resistant tape, cleaning device, antifreeze, heating device, anti-freezing roller, etc. In the belt conveyor, the system configuration is shown in Fig 4.

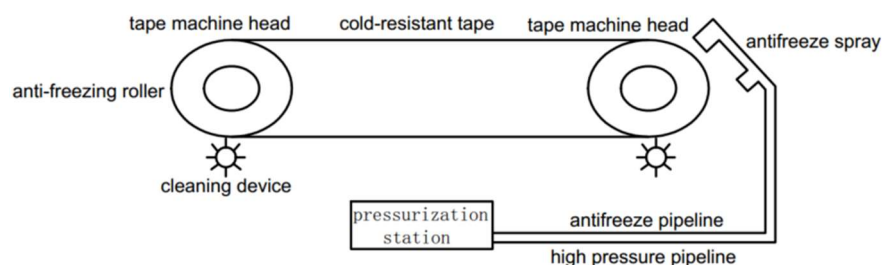


Fig.4 Belt conveyor antifreeze system configuration

5. Conclusion

The winter operation of the open pit mine in the alpine region should be combined with the actual situation of the mine to carry out production organization management, reduce the problems of winter operation equipment failure and freeze-stick, improve production efficiency, and ensure the completion of the annual production task while safe production.

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