

Underground Coal Preparation System and Applications

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Abstract: The underground coal preparation is a cutting-edge technology of the coal industry worldwide. This paper introduced the meaning of implementing the underground coal preparation, and the practical applications of underground mechanical moving screen jig, underground heavy medium shallow slot and underground air jigger. Through analyzing the main separation equipment and the advantages and disadvantages of three primary processes from aspects of process complexity, slime water treatment, raw coal preparation, etc., the difference among technology investment, construction scale, production cost and economic benefit is concluded.

1. Introduction

China is the world No.1 country in coal production and consumption. Coal production in China has been continuously over 3 billion tons annually over 5 years. In the new economic situation, especially for the importance and requirements of environmental protection, the new government has unprecedentedly required to improve the coal clean utilization. However, coal gangue, is biggest environmental pollution source generated by coal production.

Coal gangue in large quantities not only cause ash content increasing and poor coal quality, but also bring many problems during coal washing, transportation and sales. Therefore, the earlier to remove gangue from raw coal, the more benefit can be generated. During the continuous exploration in this field, underground raw coal preparation is a significant innovation in recent years for coal washing industry. It integrates coal preparation and coal mining, and becomes an advanced technology in coal industry worldwide. As a new thing, underground coal preparation is attracting more attention for its significant economic and social benefits.

2. The significance of implementing underground coal preparation

The purpose of underground coal preparation is to avoid the lump coal gangue coming up to the ground, which can generate enormous economic and social benefits:

(1)Release coal mine productivity. By discharging coal gangue underground, the additional equal quantity of coal can be transported to the surface which brings more profit.

(2)Leave lump gangue underground to reduce land occupation and to save waste discharge fee and transportation fee so as to reduce the production cost.

(3)Lump gangue can be used for filling to replace coal. Gangue filling is the best way to solve the problems of mining under kinds of constructions or natural structure.

(4)Lump gangue discharged underground can relieve environment pollution significantly. Ground gangue dump generates dust and noxious gas which not only endanger human and animals, but also destroy vegetation and acidize soil. Meantime, ground gangue dump occupies large amount of land.



According to some statistic number, China lost 900km² land occupied or destroyed by solid waste dump of mines, two third of which is cultivated land[2]. Currently, coal gangue in China accumulated has been over 5 billion tons, and this number is still increasing by 0.3-0.35 billion tons annually.

(5) Increase income by improving coal quality. Through underground coal preparation, ash content of raw coal reduces dramatically and this saves a large amount of money for ground coal washing plant.

(6) Underground coal preparation can save a lot of construction fee up to 30%.

(7) Underground facility doesn't need heat supply which also saves money during winter operation.

Underground coal preparation accords with national idea of development of environmental protection. With higher and higher environmental requirement, China government is getting much stricter with solid waste discharge ('...coal gangue, washed rejects, coal slime must be utilized comprehensively and are not allowed to be discharged or stockpiled long term while preventing self-ignite measurements are required for temporary stock.').

3. Differences of separation techniques

Below are the separation technique flow charts of three applications as 'figure 1-3':

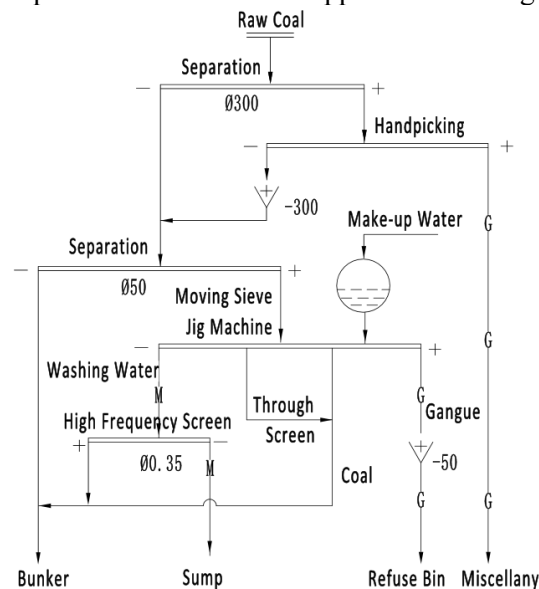


Figure 1. Underground mechanical moving sieve jig separation flow chart

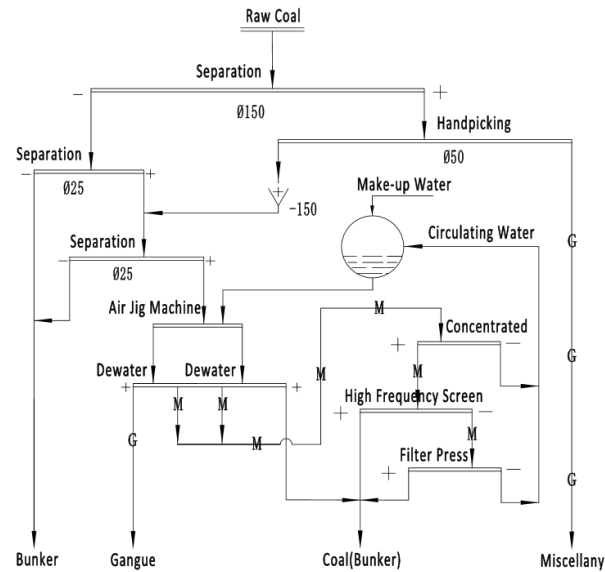


Figure 2. Underground air jig separation flow chart

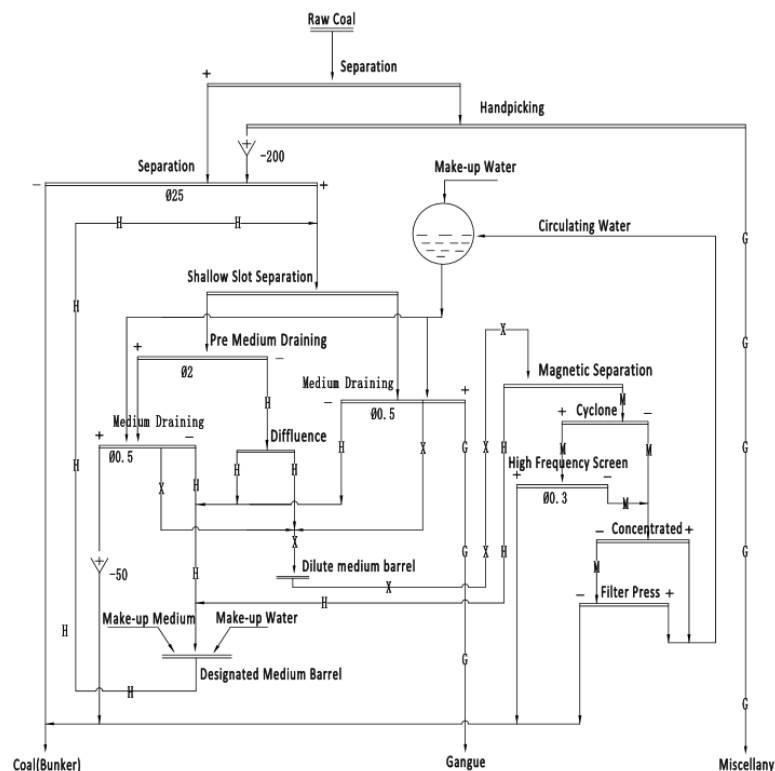


Figure 3. Underground heavy medium shallow slot separation flow chart

3.1. Technique complexity

Comparing the above three type of techniques, moving sieve jig separation is the most simple and the heavy medium shallow slot separation is the most complicated. The air jig separation is between the other two. Moving sieve jig separation technique includes raw coal preparation, separation and product transportation. Air jig separation technique includes preparation, separation, dewater, coal slime treatment and product transportation. Heavy medium shallow slot separation technique has six

sub-systems of preparation, separation, medium draining, medium recycle, coal slime treatment and product transportation.

3.2. *Coal slime treatment*

The coal slime treatment systems of heavy medium shallow slot and air jig separation technique are much more complex than the one of moving sieve jig separation technique. Coal slime treatment is critical for coal washing. These treatment differences among the three types of techniques are based on following reasons:

The recycled water consumption of moving sieve jig separation system is very small down to 0.1m³ per ton and meanwhile the system is not strict with the concentration of coal slime so that its treatment can be simplified or excreted into shaft sump directly.

For shallow slot separation system, the medium has strict requirements for content of slime and water. The medium draining process needs a mass of clean circulating water as spray water which consumption can be about 1 m³ per ton. Therefore heavy medium shallow slot system must have coal slime water clarified, magnetic separation and bypass systems so as to exclude redundant slime or water content in recycled medium, then to guarantee the working medium stability during recycling and reusing the medium.

For air jig separation system, even more recycled water is needed and the consumption can be about 3m³ per ton. To get better separation effect, it is much better to use clean water. So the coal slime water treatment is additionally needed to ensure recycled water meet the requirements.

Whether heavy medium shallow slot separation or air jig separation system, the recycled water consumption is too high which is impossible to be discharged into shaft sump directly, otherwise it would affect mine water system. However it is much flexible according to site conditions for moving sieve jig separation system.

3.3. *Raw coal preparation*

The above techniques all need raw coal preparation which is basically the same except for the different separation size. Underground moving sieve jig needs particle size up to 300mm, while the shallow slot and air jig need 150mm.

The upper limit particle size for moving sieve jig process is 350mm and the lower limit is 30mm. The optimum separation granularity is 300-50mm. For underground moving sieve jig separation, the material movement is driven by the up and down movement of the sieve which has no influence to movement of the larger granularity particles, therefore the upper limit can be much bigger.

The upper limit size for heavy medium shallow slot process is 200mm and the lower limit is 13mm. The optimum separation granularity is 150-25mm. When it works, the transportation of lower density material relies on the impulsion force of horizontal flow inside. The bigger particle size is, the larger flow rate of recycled medium it needs. Hence it is not suitable for particle size larger than 200mm; otherwise the flow rate would be too large to be reasonable.

Air jig separation process has the upper limit size for 200mm and the lower limit for 13mm as well. The optimum separation granularity is also 150-25mm. During its working, the material's transportation inside the chamber is driven by the combined action of compressed air and water, especially the translocation of water. Too big size of particle will affect the separation and transportation, and cause the stacking of large granularity particles which will move slowly. This is the reason why its upper limit is 200mm.

There is some material larger than 200mm in raw coal. So it must be removed by raw coal preparation to meet the upper limit of heavy medium shallow slot and air jig separation. While there is relatively less material larger than 350mm, so the raw coal preparation could be much simplified.

No matter which type of separation technique, it needs dedicated raw coal preparation process according to the composition features of raw coal granularity.

4. Main separation equipment and the advantages and disadvantages of three types of separation techniques

The advantages and disadvantages of three types of separation techniques exist because of the difference of their operating principles.

Heavy medium shallow slot coal preparation: high separation precision, high processing capacity for single unit; but system is relatively complex, and the operation and maintenance costs are high. It is strict with the slime content in raw coal, and also sensitive to the variation of coal slime. Its slime water treatment is relatively complex.

Moving sieve jig coal preparation: the upper limit of processing granularity is up to 350mm. The recycled water consumption is very less and not strict with concentration of slime water; the corresponding treatment system is simple. The whole system has less production processes and is much easier to be managed. The production and operation costs are low, but comparing with heavy medium system, the separation precision is relatively low.

Air jig coal preparation: air jig has long history and the process flow is relatively simple which brings convenience for operation and maintenance. The production cost is relatively low. The system is not limited by the separation density and can realize high density separation. The disadvantage is that it needs high volume of recycled water which cause high system load of washing water, and its separation precision is low.

Table 1. Part technical data of separation equipment

Main separation equipment	Separation condition	Separation granularity	Separation precision	Processing capability unit width (t/m·h)	Recycled water flow rate (medium flow rate)	Quantity efficiency
Moving sieve jig	c.p	350—30	I=0.09—0.10	80—110	10—20m ³ /m ² ·h	≥95
Heavy medium slot	c.p	13—200	Ep=0.02—0.04	70—100	175—200 m ³ /m·h	≥98
Air jig	c.p	13—200	I=0.11—0.13	90—110	3.0—3.5m ³ /t	≥90

c.p: coal preparation

Through the above chart, the separation precision and quantity efficiency of heavy medium shallow slot is the highest.

5. Investment, construction scale, production cost and economic benefit differences

The advantages and disadvantages of three types of separation techniques exist because of the difference of their operating

5.1. Investment, construction scale and production cost

The different techniques cause different system investment and production costs:

Table 2. Underground coal preparation investment and construction scale

Underground c.p system	Equipment units required	Total power	Main separation equipment capacity	Coal gangue discharged per year	c.p system capacity per year	Equipment investment (thousand Yuan)	Ton coal production cost (Yuan)
				(thousand ton)			
Moving sieve jig	13	300 kW	820	536	4000	6000	3
Heavy medium slot	27	700 kW	600	280	1500	6530	12
Air jig	24	650 kW	600	200	1300	6200	7

The above chart shows that the investment per ton coal of moving sieve jig coal preparation is the lowest, while the one of heavy medium is the highest. The same happens when it comes to production cost.

5.2. *Economic benefit*

The economic and social benefit of underground coal preparation has been stated in front. The economic benefit is mainly reflected in the additional coal production and coal gangue transportation cost saved as well as the ground gangue innocent treatment cost saved after the coal gangue is discharged underground. No matter which coal preparation process is adopt, the coal mine system can release certain amount of productivity instead of coal gangue left underground which will obtain huge profit annually even without mining and backfilling costs.

6. Conclusion

To implement underground coal preparation has significant benefit for coal mine development. It has been proven to be a highly effective way to improve coal mine profitability and to reduce environment stress. Based on analysis of different systems in terms of process complexity, investment, construction scale, production cost and profit, etc., using moving sieve jig turns out to be the most cost effective choice among the current mainstream coal preparation methods.

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