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Application of paste backfill technology based on the gravel and unclassified tailings in Axi Gold Mine

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Abstract

The downward tunnel-type mining and subsequent backfill, a mining method which requires a rather high strength, is used in Axi Gold Mine, Xinjiang Province, China. In order to meet the strength requirement of more than 4 MPa after curing for 28 days, the paste filling system based on gravel and unclassified tailings was put forward, with the ratio of cement, tailings and gravel being 1:4:2. In the backfilling system, the unclassified tailings of low mass fraction from concentrating mill is dewatered to a mass fraction of more than 60% through a deep-cone thickener with 18 m in diameter. Meanwhile, the gravel collected from stripping waste rock in an open-pit mine is ground to a particle size of less than 16 mm. The unclassified tailings of high mass fraction, the ground gravel and Portland cement are then measured in accordance with the recommended ratio and mixed thoroughly in a continuous twin-shaft mixer (type: JS3200) to form a paste slurry. Finally, the paste is pumped to the stope with a filling pump (type: HGBS120.15.320). This paste backfill technology, based on gravel and unclassified tailings, has such advantages as high strength, low bleeding rate and outstanding tight-filling ratio, etc., not only ensuring safe underground operations, but also providing a way for tailings disposal. The successful application of this technology in Axi Gold Mine has brought huge economic and environmental benefits.

1 Background

Axi Gold Mine (AGM) in Xinjiang Province, China, is affiliated to the Western Gold Yili Co, Ltd. Since its launch in 1994, a large number of mined-out areas have been formed, not only causing the surface subsidence that affects the surrounding environment but also threatening the safe production of the mine at present and even in the future. Furthermore, the traditional open-stope method used requires setting aside pillars of certain specifications, which inevitably leading to the loss of resources.

In order to reduce the effects of mining on the local environment, improve the safety of underground operation, and maximize the recovery of valuable mineral resources at the same time, a downward tunnel-type mining (DTM)and subsequent backfill were designed to ensure the safe underground operation and alleviate the pressure of tailings dam.

However, because of the rather fine particle size of the tailings in AGM (the particles with the size below 400 mesh accounted for 57%), the strength of backfill after curing for 28 days is still rather low even though the cement/sand ratio is 1:4, which cannot meet the required strength (after curing 28 days) of 4.0 MPa in DTM.

Therefore, to effectively improve the low strength caused by high content of ultrafine tailings, gravel paste tailings filling system utilizing gravel and unclassified tailings was designed for this project.

In this project, backfill experiments were firstly conducted to determine the reasonable filling equipment required. The main focus of this paper is on the concentrating, stirring and pumping equipment.

2 Process of backfill system

Firstly, tailings from the concentrating mill was transported to a deep-cone thickener of 18 m in diameter located in the backfill station. Meanwhile, flocculants were added to improve the sedimentation rate of tailings and reduce the solids contained in the overflow water.

Secondly, the overflow water flows to a backwater pool by the side of the deep cone thickener and is used for backfill production. The surplus of the overflow water is transported back to the concentration mill where the tailings can be concentrated to a mass fraction of more than 60%, before being transported to a 2-level mixer.

The water used for controlling the mass fraction of the mixture was then transported to the 2-level mixer after measured from the backwater pool.

Besides, cement is supplied by a powder tanker and blown to the cement silo by compressed air. The cement is then transported to the 2-level mixer after measured by flow-steady device and powder scale. In the meantime, the gravel is fed to the 2-level mixer through a belt conveyor.

Finally, the tailings with high mass fraction, cement, gravel, and water are mixed in the 2-level mixer to form a uniform paste. After mixing for approximately 5 min, the paste is pumped to a stope through a filling pump.

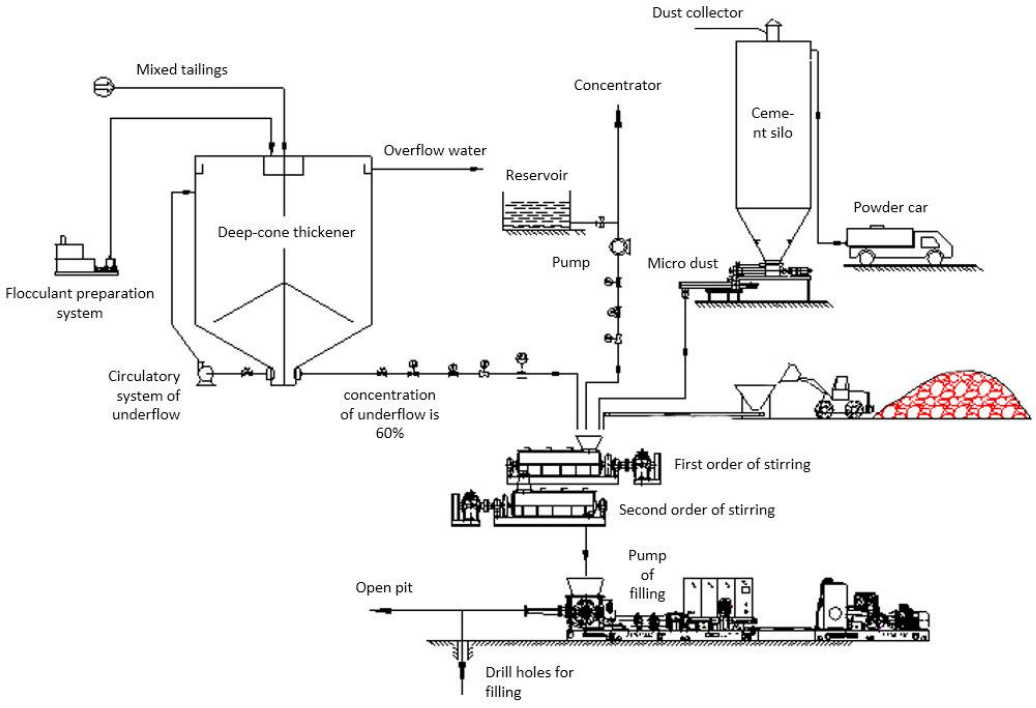

Figure 1 The process of backfill system

3 Main filling equipment

3.1 Deep-cone thickener

The tailings from the concentrating mill was concentrated in a deep-cone thickener to a mass fraction of more than 60%, which meets the requirement of backfill technology.

According to the experimental results of both static and dynamic sedimentation as well as that of the semi-industrial tests of deep-cone thickening on tailings in AGM, the reasonable tailings handling capacity per unit area is (0.30 to 0.60) t/(m^2·h). Therefore, a deep-cone thickener of 18 m in diameter was selected in this case.

The deep-cone thickener selected is center driven, with the main drive being a turbine reducer with low speed and large torque; its shell is a steel structure. The thickener is equipped with the control system, flocculants system and tailings feed port. In addition, other parts such as screw, rake frame, cone scraper, bottom row paste and so on revolve around the central vertical axis in the lower part of the shaft. Overall, the deep-cone thickener has the following characteristics:

- Slurry is fed tangentially and the vortex can be offset by the vertical baffle.
- An automatic dilution device is used to better dilute the tailings slurry.
- The diversion cone can improve the slurry dewatering process, solid content in the overflow and the final mass fraction of underflow.
- A high efficiency flocculant feeding cylinder is set to ensure the best flocculation efficiency.
- The thickener features a large handling capacity and small area of land occupation. Compared with that of a conventional thickener, the area required to handle the same amount of tailings in the deep-cone thickener can save a land area of approximately 20%.
- With the solids contained less than 300 ppm, the overflow water features a high quality and thus can be recycled.
- The mass fraction of underflow is high, which can produce paste of higher mass fraction.
- The hydraulic driving device and the automatic rake lifting device are used to provide three level protection measures.

Figure 2 The application of deep-cone thickener in AGM

3.2 Continuous twin-shaft mixer

The JS320 twin-shaft mixer specifically designed for paste transportation was used in this system to mainly transport systems of fine particles of high mass fraction and mix the crushed construction materials. The mixture of tailings, river sand, sea sand, cement and fly-ash can be stirred in this mixer. Overall, the mixer has the following characteristics:

- The mixture is driven by motor speed reducer with simple structure and strong adaptability.
- The stirring effect is obvious with the forced mixing process.
- The mixing blade is made of high quality steel with good abrasion resistance and long service life.
- Double sealing with labyrinth packing ensures desired sealing effects.

- The high mass fraction of slurry can be mixed well to realize continuous feeding with large capacity.

Figure 3 JS3200 continuous twin-shaft mixer

3.3 Filling pump

According to the maximum backfill flow rate of 90 m^3/h in the backfill system as well as the safe coefficient of 1.2, two filling pumps (type: HGBS120.15.320) with the maximum capacity of 120 m^3/h and maximum pumping pressure of 15 MPa were selected (one in operation and one standby). In order to save energy, the actual demands in different working conditions can be controlled by the pump whenever necessary.

The HGBS120.15.320 filling pump is specifically developed for backfill, and has been widely used in underground and open-pit backfill to handle the solid waste and polluted water. It can work continuously for a considerably long period of time to ensure the steady transportation over long distance and the maximum improvement of backfill area.

In brief, the HGBS120.15.320 fill pump has the following characteristics:

- Hydraulic control: the open system of hydraulic control has such advantages as low temperature, high reliability, little impact and outstanding self-cleaning ability.
- Constant power control: the hydraulic system with twin-pump was used and the power can be controlled in a constant amount, which makes the system more simple and reliable.
- Concrete piston automatic return: convenient and fast checking and replacing of piston; simple and reliable structure.
- Components with high wear resistance and long service life are used, such as glasses board, cutting ring, S-type pipe valve and so on.
- Energy-saving: a variety of variable technology is used in the hydraulic system, realizing the proportional control and output based demand and saving energy with high efficiency.
- Automatic lubrication: automatic lubrication with hydraulic synchronous control is used to ensure the desired performance of lubrication components such as concrete piston, mixer and S-type pipe valve.
- S-type tube valve: the S-type valve designed with a big mouth increases the inner diameter, suction area and suction efficiency and improves transportability as well.
- Anti-dead angle in hopper: with the double arc welding structure of the hopper, materials cannot be accumulated.

Figure 4 HGBS120.15.320 filling pump

4 Conclusions

The paste filling system based on the use of gravel and unclassified tailings was built in AGM in June, 2016, and put into use in Sep., 2016. The following progress has been achieved so far.

- The mass fraction of paste is high, the sedimentation rate is low, and the roof-touch efficient is satisfactory. Besides, the backfill is strong enough to support the roof rock.
- The paste is steady and has a less wear on pumps and mixers. Furthermore, the flow rate is low and ensures the steady operation of the system.
- The bleeding of paste is almost eliminated and the cement loss can be controlled at a low level, which can efficiently improve the underground environment and save the cost of disposing the water and mud in underground filling.
- The deep-cone thickener was used for dewatering the tailings and can significantly reduce the solids content in the overflow water, and recycle the water to save the cost.
- The paste filling system based on gravel and unclassified tailings with the ratio of cement, tailings and gravel being 1:4:2 can meet the strength requirement of more than 4 MPa after curing for 28 days, when the downward tunnel-type mining and subsequent backfill are used.
- The lower cement consumption reduced the filling cost greatly. In AGM, the cement consumption used in the conventional backfill system was 0.24 t/m^3, while it is 0.09 t/m^3 in this paste backfill system. That means, 40.5 yuan/m^3 of backfill can be saved assuming the cement price is 270 yuan/t. With a capacity of 200,000 m^3 per year in AGM, approximately 8100,000 yuan can be saved per year.

To summarize, the paste backfill system based on gravel and unclassified tailings has such advantages as great strength, low bleeding rate and outstanding roof-touch, which can thus ensure the safe underground operation and release the pressure in the tailings dam at the same time. It has been proven that this advanced technology not only greatly benefits economy and environment, but can also be referred to by other mines.