Technology and Practice of Mechanized Backfill Mining for Water Protection with Aeolian Sand Paste-like

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ABSTRACT

The technique of mechanized mining backfill with aeolian sand paste-like was invented. Aeolian sand was used as aggregate and alkali-activated fly ash as cementing agent in the backfill. The ratio was studied that the water-sand ratio was 1:1.3, the mass concentration was 72%, and the filling slurry’s initial fluidity reached 210mm. The filling capacity reached 360m³/h and the running energy consumption was low with adopting the filling station model of double pulping system and underground equipment pool. Industrial test showed that the technique met the requirements of water resources protection, based on that the filling rate was 98.5% in goaf, strata behavior appear slightly, roof water leaching was less than 2m³/d, and surface subsidence value was 38mm. Meanwhile, there were great breakthroughs in cost and production efficiency comparing with similar technology.¹

INTRODUCTION

Compared with the mining method for reducing overlying strata damage degree to protect water by reducing resource recovery such as strip mining, limited mining, backfill mining is the ideal green mining to control rock movement by filling solid or cemented material in goaf with no loss of coal resources. In recent years, the backfill mining technology with waste gangue, fly ash as main backfill material has been rapidly developed and applied in mining under building (structure) and around water in east-central mining area, and remarkable benefits of economic and environment have been achieved. Aimed at

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the urgent need for water protection in mining and extensive occurrence of aeolian sand in northwest coal mining area, it is imperative to actualize backfill mining with aeolian sand as aggregate. Fan Limin proposed the filling mining technology program with aeolian sand for water conservation. Yan Shao hong presented a new gateway and pillar top coal caving mining method for water protection. Cui Feng and others tested the basic properties of aeolian sand and the performance of cemented backfill materials with Aeolian sand as aggregate[1~5]. Above results have promoted the development of aeolian sand backfill mining technology, but the systems of slurry preparation and backfill mining based on aeolian sand have not been formed, and engineering practices are also absent. In addition, the efficiency of backfill mining is related to its application value, so it is important to improve the production capacity and reduce the cost of materials, processes and systems. The author and his team developed aeolian sand paste-like backfill materials with excellent liquidity, established 14.9 times line of self-flowing transportation system, and adopted the filling station mode of low energy consumption with double pulping systems, and formed aeolian sand paste-like backfill mining technology with relatively high efficiency and low cost based on 3 years research.

CHARACTERISTICS OF AEOLIAN SAND PASTE-LIKE BACKFILL MATERIAL

The Composition of Backfill Material

(1) AEOLIAN SAND

There are black dust, weeds and more loess tuberculosis in the area no deeper than 50cm because of being blown, transported and accumulated by wind, and fewer impurities, pure yellow, colorless aeolian sand particles in the area deeper than 50cm in Yuyang Coal Mine surface. 28 sand samples were collected, and the main minerals of quartz, feldspar, mica were observed through microscope; X ray diffraction analysis showed that chemical compositions of SiO2, Al2O3, CaO, Fe2O3 and MgO were included, and main components of SiO2 and Al2O3 accounted for 65.75% and 12.83% respectively; screening test showed that the aeolian sand was a super fine sand which most size of concentrated was 0.075mm~0.6mm, and the average size was 0.249mm, and the maximum was no more than 1.0mm.

(2) CEMENTING MATERIAL

Alkali activated cementing material is a new type of non-metallic cementitious material which is developed recently with volcano properties or potential hydraulic city materials (such as slag and fly ash) as main material, and it is stimulated the activity to generate hydraulic cementing performance by adding alkaline agent. The material made full use of industrial wastes, and it is low cost, and its properties of strength, acid and alkali resistance, carbonation
resistance are better than that of Portland cement. Fly ash was chosen as the main material, and lime, gypsum, cement as alkaline agent in this cementing material of backfill material.

(3) WATER

Mine water can be used in preparation of backfill materials.

Proportioning Experiment of Backfill Material

The rheological parameters (fluidity, viscosity, yield stress) of backfill slurry, final setting time, bleed ingrate, strength of backfill body is the main performance index of cement backfill material. 2 factors and 4 levels orthogonal experiments were adopted to test the performance of different ratio backfill with mass concentration of 66%, 69%, 72%, 75%, 1:0.7, water-sand ratio of 1:1, 1:1.3, 1:0.4. The measurement of slurry flow is as shown in Figure 1.

Compared with the current backfill materials used in mine, aeolian sand paste-like is characterized by excellent liquidity and high strength From the standpoint of meeting performance indicators and as much as possible using of Aeolian sand, the program of water sand ratio 1:1.3, mass concentration 72% was chosen finally.

![Figure 1. The fluidity test of aeolian sand paste-like.](image.png)

THE FILLING STATION MODE OF LOW ENERGY CONSUMPTION WITH DOUBLE PULPING SYSTEMS

Aeolian sand paste-like backfill preparation system consists of initial slurry tanks, auxiliary tanks (storing activator), cement tanks, slurry tanks, aeolian sand sieving & conveying systems and fly ash bases. The pulping process was that: quantity of water was injected into the initial slurry tanks, and stirring motor was started, and fly ash was injected to make initial slurry; the eccentric horizontal synchronous sieve (screen size 25mm) was adopted to clean aeolian sand material, and sand product was conveyed and metered through belt conveyor and electronic belt; and the initial slurry, ingredients, cement and aeolian sand were
transported to the slurry tank in accordance with the proportion and mixed uniformly. Automatic control was adopted in whole process of material feeding, liquid level monitoring and so on.

The pulping capacity of filling station is commonly only 60~150m³/h, and single system is always operated, which is one of the factors that restrict the production capacity of backfill. In view of this, two sets of 180m³/h pulping system were adopted and centralized to simultaneously operate in the filling station, and the plane is shown in Figure 5(a). The maximum filling capacity can reach 360m³/h due to the slurry prepared carrying to the work face by 2 pipelines.

There are great waste of energy consumption and operation cost in the water, ash, material supplying process because of the high storage tank. In view of this, the filling station was designed as underground equipment pool mode: initial slurry tanks, auxiliary tanks, cement tanks were placed underground 10m, the top of tanks were parallel to the ground, so ash can be fed horizontally; the system of aeolian sand storing, screening and conveying were arranged from ground to lower 10m, aeolian sand could be naturally transported down in the screening; slurry tanks were placed underground 15m, central of the pool, and its top was parallel to the bottom of the said equipments, and initial slurry and all kinds of materials could be transported horizontally, which has achieved obvious effect of reducing energy consumption.

**PRACTICE OF MECHANIZED COAL MINING WITH AEOLIAN SAND PASTE-LIKE**

**Operation of Mining and Filling System**

In October 2012, the mechanized mining backfill system with aeolian sand paste-like was built in Yuyang Coal Mine, and industrial experiment was carried out at the end of November in 2307 working face. By mid of December 2013, the working face was advanced for 310m, 213 thousand tons coal were mined, about 170 thousand m³ slurry were filled, 85 thousand tons mine water and 83 thousand tons and 12 thousand tons activator and 111 thousand tons aeolian sand were consumed.

**Water Preserving Effect**

A total of 72 mining filling cycles were carried out in the working face. The situation of filling body's connection with top along the working face in each cycle was observed and recorded. Statistical results showed that the average filling rate in goaf was as high as 98.5% because of low bleeding rate and strict site management.

The maximum subsidence was 38mm, which was located at the 22# measuring point, distance from cutting hole 196m. Buildings on surface were not affected. The results showed that the damage of overlying strata was slight in mining filling with aeolian sand paste-like, and the effect of protecting water resources under mining was realized.
Production Efficiency and Cost

According to the author’s research statistics, the production capacity of single cemented backfill mining working face was 200~300 thousand t/a, and ton coal filling cost was 110~140 yuan in mine at present. In contrast, the production capacity of mechanized mining filling with paste-like could reach 200~300 thousand t/a, which was increased nearly 2 times by using large capacity of filling system and whole backfill space sealing; ton coal filling cost was about 81.5 yuan, and reduced by 35% because of adopting optimization measures such as using local aeolian sand materials, simple pulping process, filling station with low energy consumption, self-gravity transportation, and less cloth consumption.

CONCLUSIONS

(1) Aeolian sand was used as aggregate and alkali-activated fly ash as cementing agent in the backfill material. Slurry ratio was studied that the water-sand ratio was 1:1.3 and the mass concentration was 72%.

(2) The low energy consumption arrangement mode and double pulping systems were adopted in the filling station, which improved the filling efficiency and reduced the cost.

(3) The monitoring results of filling rate, support resistance in working face, leaching water of roof, surface subsidence showed that the damage of overlying strata was slight in mining filling with aeolian sand paste-like, and the overlying aquifer could be effectively protected.

REFERENCES