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Green coal mining technique integrating mining-dressing-gas draining-backfilling-mining

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ABSTRACT

Aiming to address the following major engineering issues faced by the Pingdingshan No. 12 mine: (1) difficulty in implementing auxiliary lifting because of its depth (i.e., beyond 1000 m); (2) highly gassy main coal seam with low permeability; (3) unstable overlying coal seam without suitable conditions for implementing conventional mining techniques for protective coal seam; and (4) predominant reliance on "under three" coal resources to ensure production output. This study proposes an integrated, closed-cycle mining-dressing-gas draining-backfilling-mining (MDGBM) technique. The proposed approach involves the mining of protective coal seam, underground dressing of coal and gangue (UDCG), pressure relief and gas drainage before extraction, and backfilling and mining of the protected coal seam. A system for draining gas and mining the protective seam in the rock stratum is designed and implemented based on the geological conditions. This system helps in realizing pressure relief and gas drainage from the protective seam before extraction. Accordingly, another system, which is connected to the existing production system, is established for the UDCG based on the dense medium-shallow trough process. The mixed mining workface is designed to accommodate both solid backfill and conventional fully mechanized coal mining, thereby facilitating coal mining, USCG, and backfilling. The results show that: The mixed mining workface length for the Ji_{15}-31010 protected seam was 220 m with coal production capacity 1.2 million tons per year, while the backfill capacity of gangue was 0.5 million tons per year. The gas pressure decreased from 1.78 to 0.35 MPa, and the total amount of safely mined coal was 1.34 million tons. The process of simultaneously exploiting coal and draining gas was found to be safe, efficient, and green. This process also yielded significant economic benefits.

1. Introduction

Highly gassy mines and collieries are found all over China. These mines and collieries are mainly concentrated in Guizhou, Sichuan, Heilongjiang, Shanxi, Henan, and Anhui provinces. The Chinese statistics for 2010 has indicated that 2197 highly gassy mines account for approximately 17% of all collieries in the country. Consequently, mining levels have been extended with the increase in coal production. This development has resulted in a gradual increase in the proportion of highly gassy coal seams with low permeability. More than 95% of the coal seams in China's highly gassy mines actually have low permeability. Their permeability coefficients are less than 0.1 $m^2/(MPa^2 \cdot d)$, which makes coal exploitation and gas draining a very challenging process.

The most common mining method presently employed for highly gassy coal seams with low permeability is used in mining the protective seam, to achieve pressure relief and gas drainage before extracting protected seam [1–3]. However, this method has limitations, and requires the existence of coal or parting thin seam that can act as the protective seam. The positions of the protective and protected seams must also be aligned relative to each other. Finding suitable methods of relieving gas pressure and increasing drainage rate before seam extraction is a major challenge in mining highly gassy coal seams without the requisite protective seams. This approach can facilitate simultaneous coal exploitation and gas draining, which would lead to safe and efficient coal production.

The Pingdingshan No. 12 mine, named as No. 12 mine for short, is owned by the Pingdingshan Tianan Coal Mining Co., Ltd. The Ji_{15} coal seam of the mine is highly gassy, has low permeability, and does not have a protective seam, which is the requisite condition

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for conventional mining. This study proposes a coal mining technique that integrates the processes of mining-dressing-gas draining-backfilling-mining (MDGBM) to address the previously mentioned challenges. This framework includes various processes, including the mining of protective seam in the rock stratum, underground dressing of coal and gangue (UDCG), development of a system for exploiting coal and draining gas, and using a mixed mining technique that combines solid backfill and conventional, fully mechanized coal mining. The MDGBM technique was successfully implemented in the Ji_{14}-31010 and Ji_{15}-31010 workface, which are located in the third level of the No. 12 Mine. This result proves that the approach is safe, efficient, and green for simultaneously exploiting coal and draining gas.

2. Project overview

2.1. Background

The No. 12 mine, which is buried at a depth of 1100 m and has a production capacity of 1.3 Mt/a, is located in the Henan province. Its mining depth extends from −150 to −800 m. The remaining recoverable reserves of the mine currently amount to 23.849 Mt, 12.343 million tons (51.75%) of which is classified as "under three" coal resources. "Under three" refers to pressure-relieved coal buried under railways, waterbodies, or buildings. The first and second levels of the No. 12 mine have been fully mined. The third level has total reserves amounting to 32.323 million tons, 21.253 million tons (65.75%) of which is recoverable. The third level is also a single mining area with two wings. It is presently used as the main mining area with main coal seams belonging to the Ji group. The Ji_{15} coal seam, which has a permeability coefficient of 0.0776 $m^2/MPa^2 \cdot d$, specifically contains 15.256 m^3/t of raw gas at a pressure of 1.78 MPa. This seam is overlaid by the 0.5 m-thick Ji_{14} seam, which is a non-outburst seam with inherent instability and a gas pressure of 0.26 MPa.

Mining of the Ji_{15} seam is faced with the following challenges:

(1) The implementation of auxiliary lifting and other deep mining processes is difficult because the mining depth exceeds 1100 m.
(2) The Ji_{15} seam is highly gassy, but has low permeability and poor drainage efficiency. These characteristics pose serious potential risks and make safe mining very difficult to achieve.
(3) The overlying Ji_{14} coal seam is inherently unstable, too thin for mining, and does not have the requisite technical conditions for conventional mining of protective seams. On the one hand, abandoning the seam will result in serious resource wastage. On the other hand, designating it as the protective seam will involve mining it in the rock stratum, which will inevitably cause the coal flow to contain a high proportion of gangue (i.e., as much as 73.7%). The protective seam workface will create approximately 8.1 million m^3 of gangue, the surface discharge of which will significantly increase underground transportation and lifting costs. Secondary issues include choosing either lifting the gangue for surface discharge or treating them underground.
(4) The mine is predominantly reliant on "under three" coal resources, especially those under buildings. Therefore, its production output cannot be guaranteed. Accordingly, the engineering issue to be resolved is how to mine the J_{15} seam safely and efficiently.

2.2. Concept behind the integrated MDGBM technique

The Backfilling Mining Task Force from the China University of Mining and Technology has proposed the integrated MDGBM technique to address the engineering issues in the No. 12 mine. The basic concept behind this integrated technique is a green and cyclical mining system targeting the highly gassy Ji_{15} seam with low permeability. The MDGBM technique is entirely implemented underground and comprises the following processes: coal (rock) seam mining, UDCG, pressure relief, and gas drainage before extraction, and development of a mixed mining technique that combines solid backfill and fully mechanized conventional coal mining.

The conditions for protective seam mining are specifically created based on the basic requirements for protected seam mining. These requirements indicate that mining of the Ji_{14} protective coal (rock) seam should free the underlying highly gassy Ji_{15} seam with low permeability. The previous process produces raw coal with high gangue contents. This raw coal goes through the UDCG system. The resultant gangue is simultaneously transported to the underlying Ji_{15} seam workface, where mixed mining (i.e., solid backfill and conventional fully mechanized coal mining) is conducted. The backfill mining technique is subsequently used for goaf backfilling [4–15]. Protective seam mining increases the protected

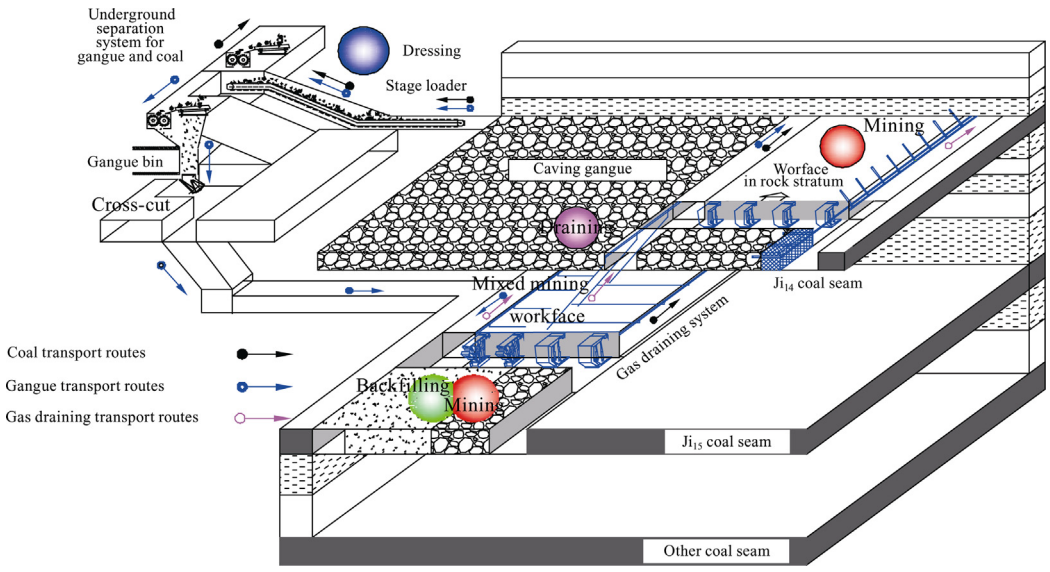

Fig. 1. Overall concept behind the integrated MDGBM technique.