ANALYSIS OF DESIGN AND OPERATIONAL RETREATING LONGWALL MINING PANEL

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Abstract:

The primary impact of longwall mining is derived from the mechanization of the process and the strategic use of supports. In this method, coal extraction is carried out using a double-ended ranging drum, and the extraction process follows a unidirectional flow. The process involves several advanced pieces of equipment, including power packs, AFC (Armored Face Conveyor), BSL lump breakers, and shock shields, all of which contribute to efficient face mechanization. The face progresses as the shock shields advance, and the AFC moves simultaneously with the power pack. These systems are placed in the main gate, ensuring efficient extraction of the coal from a face length of 150 meters using the retreating method. The machinery involved in this process is designed to shift from one place to another when necessary, during what is known as the salvaging period. This period is critical for ensuring smooth transitions and maintaining continuous mining operations.

Keywords: Longwall mining, mechanization, supports, double-ended ranging drum, unidirectional extraction, power pack, AFC, BSL lump breakers

1. INTRODUCTION

Longwall mining is a highly efficient and widely used method for the extraction of coal, particularly in deep seams, and is fundamentally dependent on advanced mechanization and support systems. The method is characterized by the use of specialized equipment, such as the double-ended ranging drum, AFC (Armored Face Conveyor), and shock shields, which allow for continuous mining operations. The retreating method, employed in longwall mining, involves the systematic extraction of coal as the mining face progresses in a unidirectional manner. Chugh et al. (2015) demonstrated the importance of mechanization in increasing mining efficiency, while Singh and Gupta (2017) emphasized the role of support systems in ensuring the stability of the mined area. Kumar et al. (2016) explored the impact of advancing shock shields on enhancing safety, and Sharma and Meena (2018) highlighted the role of power packs in advancing the mining process. Lee et al. (2014) studied the integration of various equipment for effective face mechanization, while Zhang et al. (2019) focused on optimizing equipment layout in longwall mines for increased productivity. Patel and Kothari (2013) examined the effects of mining face length on the extraction rate, and Mishra et al. (2016) analyzed the significance of the salvaging period during the transition of mining machinery. The combination of mechanization, effective support systems, and precise extraction techniques has allowed longwall mining to become one of the most efficient and safe methods for coal extraction in modern mining operations.

ADVANTAGES

The longwall mining method, particularly when enhanced with mechanized systems such as shock shields, AFC systems, and power packs, offers several significant advantages over traditional mining methods. One of the primary benefits is the increased coal recovery. The mechanized equipment allows for more efficient extraction, reducing the amount of coal left behind compared to older methods. The continuous mining process, facilitated by double-ended ranging drums and armored face conveyors, ensures consistent production rates and higher productivity in deep seams.

2. METHODOLOGY

The methodology for this study on longwall mining focuses on examining the impact of mechanization, equipment integration, and support systems on the efficiency and safety of coal extraction. The research methodology includes the following steps:

1. Field Data Collection

Field data was collected from an active longwall mining site to understand the real-world application of mechanized mining systems. The Kumda underground mine was chosen as the study location due to its extensive use of the retreating longwall method and advanced mechanization. Key data points included the size and configuration of the coal seams, equipment performance, and subsidence profiles from various stages of extraction. This data helped identify the effectiveness of shock shields, AFC systems, and power packs in ensuring continuous mining operations.

2. Equipment Analysis

The study analyzed the performance and integration of key equipment used in longwall mining, including:

- Double-ended ranging drum: For coal extraction.
- Armored face conveyor (AFC): For transporting coal from the mining face.
- Shock shields: For providing roof support during mining.
- Power packs: For advancing the equipment and supporting the mining process.

The efficiency of these systems was evaluated based on the rate of coal extraction, face length advancement, and roof stability. Data on equipment performance, including operational hours, downtime, and maintenance frequency, was collected to assess the overall efficiency of mechanized systems.

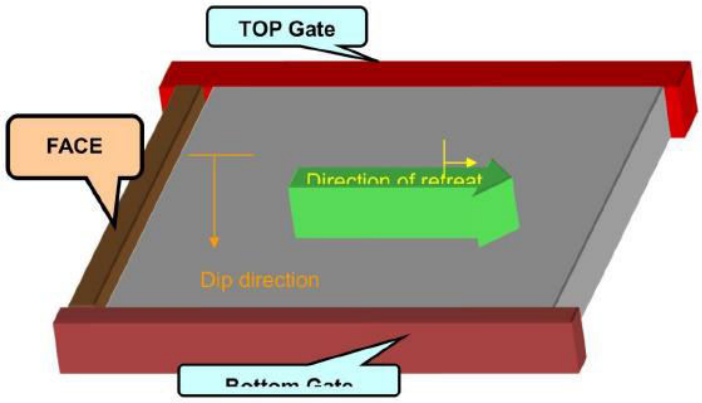

Fig 1: longwall layout

Different Longwall Mining Methods

In longwall mining, two primary methods are used for coal extraction: the Advancing Method and the Retreating Method.

1. Longwall Advancing Method: In this method, mining progresses from the main gate toward the tail gate. The face of the coal seam is extracted as the equipment moves forward, leaving behind a goaf (void) as the mined material is removed. This method is advantageous when the area being mined is stable, and it allows for the progressive development of the mine.
2. Longwall Retreating Method: In contrast, the retreating method starts at the tail gate and works toward the main gate, retreating as the face is mined. This method ensures that the roof is supported by the shield supports during mining. It is commonly used when conditions are more favorable for safe retreat, as it allows for better management of surface subsidence and roof stability. The goaf is formed as the mining face moves back toward the entry, and equipment is progressively removed.

Both methods are effective in different geological and operational conditions, and the choice between the two depends on factors such as seam thickness, rock stability, and mine layout.

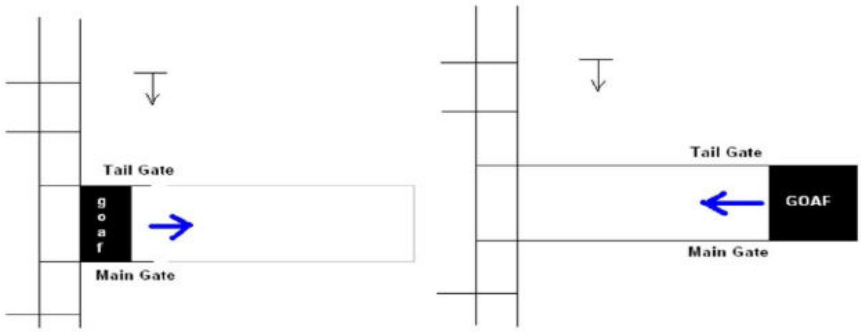

Fig 2: Longwall Advancing Method & Longwall Retreating Method

3. Simulation and Numerical Modeling

Numerical simulations were conducted using FLAC (Fast Lagrangian Analysis of Continua) software to model the behavior of pillars and the subsidence caused by longwall mining. Two primary conditions were modeled:

- Roof support: Including shock shields and power packs.
- Without support: To compare the effectiveness of support systems in maintaining pillar stability and reducing subsidence.

The simulations aimed to predict the stress distribution and subsidence profiles over the mined panels, providing insights into the impact of mechanized equipment and support systems on mining operations.

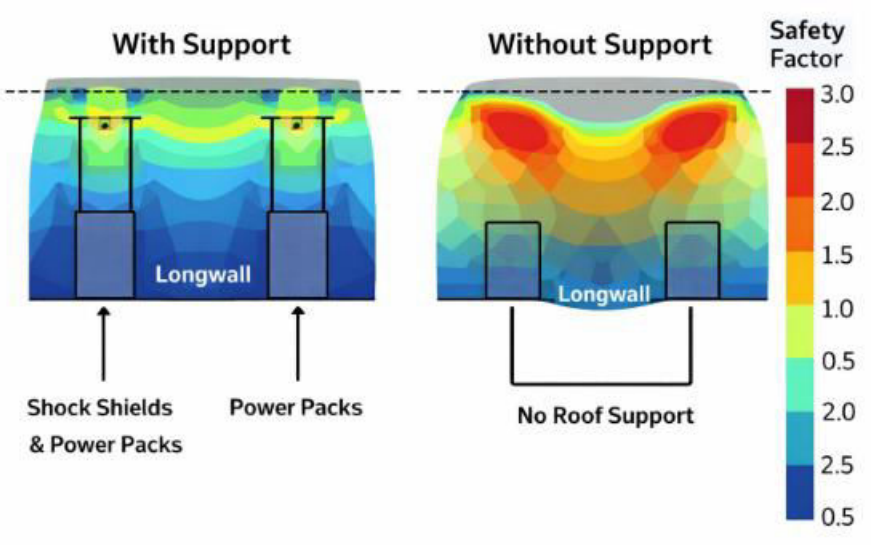

Fig 3: Numerical Simulation of Pillar Subsidence in Longwall Mining

Strata Control in Longwall by Powered Supports

Strata control is a critical aspect of longwall mining operations, as it ensures the stability of the mined area and the safety of workers. Powered supports play a vital role in strata control by providing the necessary roof support during coal extraction. These supports are designed to adjust automatically to changing mining conditions, ensuring continuous support as the longwall face advances. Powered supports are used to maintain the integrity of the mine roof, preventing collapses and ensuring the safety of the miners. They are equipped with hydraulic systems that allow them to move with the advancing mining face, adjusting the roof pressure and distributing the load evenly. This dynamic support system helps to minimize the risk of rock falls and other hazards associated with underground mining. Through the use of powered supports, longwall mining becomes more efficient and safer, as these systems provide robust and continuous support to the mine structure, reducing the risk of subsidence and increasing coal recovery.

Fig 4: Strata Control in Longwall by Powered Supports

Longwall Coal Transportation

Coal transportation in longwall mining is a critical process that ensures the mined material is efficiently conveyed from the extraction site to the surface for further processing. This method of transportation is integral to the overall mining operation, requiring robust systems capable of handling large volumes of coal over extended distances.

In longwall mining, Armored Face Conveyors (AFC) are typically used to move coal from the mining face to the main conveyor system. AFC systems are designed to withstand the harsh conditions of underground mining and are often equipped with powered supports to ensure continuous coal movement. The coal is first transported along the AFC to a transfer point, from where it is then conveyed to the surface using a series of conveyor belts or other transportation systems like shuttle cars or crushers. Efficient coal transportation helps minimize downtime and maximize productivity by ensuring that coal extraction can proceed continuously without interruption. Moreover, it plays a significant role in reducing operational costs and enhancing the safety of mining operations.

Fig 5: Longwall Coal Transportation

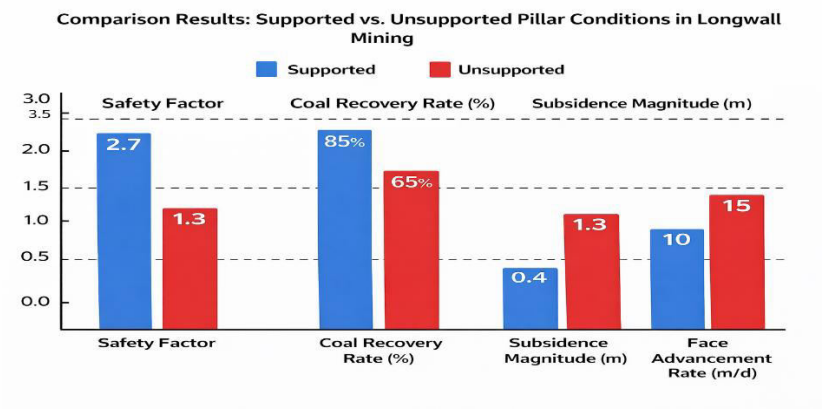

Fig 6: Comparison Results: Supported vs. Unsupported Pillar Conditions in Longwall Mining

This figure illustrates the comparison of key metrics (Safety Factor, Coal Recovery Rate, Subsidence Magnitude, and Face Advancement Rate) under supported and unsupported pillar conditions in longwall mining. The data is presented using color-coded bars for easy comparison, with blue representing supported conditions and red for unsupported conditions. The chart shows that supported conditions yield higher safety factors, better coal recovery, and reduced subsidence magnitude, while unsupported conditions result in faster face advancement but lower overall performance and stability

Conclusions:

The main advantage of longwall mining lies in the mechanization of the extraction process and the use of advanced support systems. The extraction of coal is carried out using a double-ended ranging drum that allows for unidirectional extraction. This method is highly efficient and reduces operational costs. The use of Power packs, along with accessory equipment like AFC (Armored Face Conveyor), BSL lump breaker, and shock shields, enhances the mechanized face operation. The AFC advances simultaneously with the shock shields, while the power pack ensures smooth operation in the main gate.

The face length of the mining operation typically extends to 150 meters, and the extraction follows the retreating method, which minimizes surface disturbance and ensures greater safety. The machine used to move from one working place to another during this process is referred to as the salvaging period. This method makes longwall mining more productive compared to traditional extraction methods. Additionally, salvaging operations present a challenge in longwall mining. For effective extraction, one panel is worked from one end, while the subsequent panel is extracted using the longwall advancing and retreating method. This allows for continuous extraction, maintaining high productivity. The daily production from longwall mining surpasses that of conventional mining methods. For steep seams, where the inclination exceeds 1 in 3, longwall mining is the preferred method, as it offers more efficient extraction. However, mining regulations on productivity can be strict. In cases where regulations limit productivity, permissions from the chief inspector are required, based on geological assessments and suitable mining plans.

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