pit problem, the block scheduling problem and the grade control polygon problem. In the ultimate pit problem, this paper specifically shows how to extend the problem to support a minimum mining width, a coveted result for many mining engineers.

Conclusion

Maximum satisfiability has proven useful in allowing us to consider more operational constraints and create mine designs that are more realistic — that is, with maximum satisfiability we can explicitly optimize with a mining width constraint. It is not clear yet whether these encodings are scalable to full-size mining problems, or what sort of work needs to be done. This paper provides at least a base framework and some avenues to explore.

One of the advantages of maximum satisfiability in general is that it is extremely useful outside of the mining industry. Many other fields use these solvers and are continuously working on and improving them. We in the mining industry should try to take advantage of this and apply these results to our problems to help us make better decisions, design better mines and create more value.

Currently, except for the grade control polygon problem, this introductory work is not suitable for immediate application on full-size, realistic problems. Additional research must be done to fully evaluate the different solvers, options and optimizations that can be done to see if this work can have real practical significance. ■

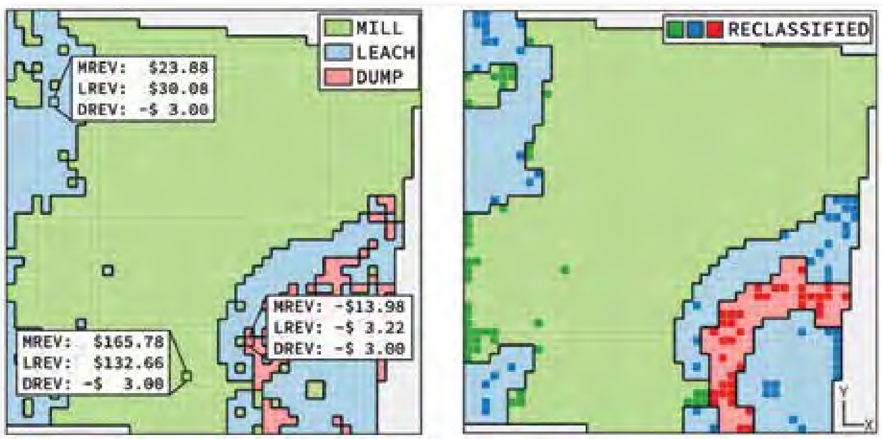

Fig. 2 The grade control polygon problem: (left) input to the grade control polygon problem, economic values for each classification for each block, and (right) output, each block assigned to the best classification such that a 3 × 3 mining width is honored and economic value is maximized, reclassified blocks are colored darker.

References

A list of references is available in the full article.

Investigating the impact of caving on longwall mine ventilation using scaled physical modeling

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Keywords: Mine ventilation, Longwall mining, Roof caving, Physical modeling

To read the full text of this paper (free for SME members), see the beginning of this section for step-by-step instructions.

Special Extended Abstract

In longwall mining, ventilation is considered one of the more effective means of controlling gases and dust. In order to study longwall ventilation in a controlled environment, U.S. National Institute for Occupational Safety and Health (NIOSH) researchers built a unique physical model called the longwall instrumented aerodynamic model (LIAM). The LIAM is a 1:30 scale physical model geometrically designed to simulate a single longwall panel. It has an 8.94 by 4.88 m (29 by 16 ft) footprint with a simulated face length of 220 m (720 ft) in full scale. LIAM is built with critical details of the *face, gob and mining machinery, and scaled to preserve the physical and dynamic similitude. This paper discusses the gob-face interaction, airflow patterns within the gob, and airflow dynamics on the face for varying roof caving characteristics. Results are discussed to show the impact of caving behind the shields on longwall ventilation.*

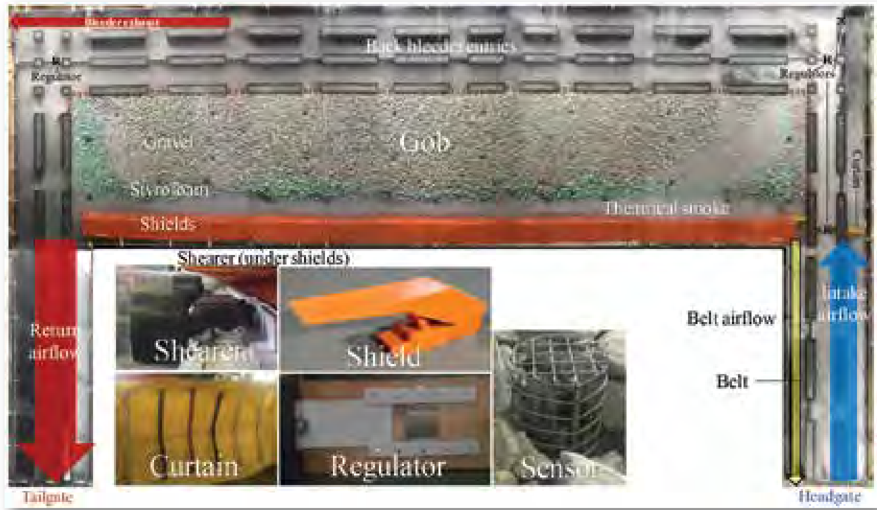

Fig. 1 LIAM in bleeder ventilation configuration.

Background

Ventilation is an important means of controlling gases and dusts in underground mines, and is critical to maintaining the safety and health of the underground workforce. Explosive methane gas is released during the mining process and can accumulate in areas that are not well ventilated. Longwall mining presents a particularly unique situation where not only are large quantities of methane gas liberated but large methane reservoirs are created concurrently. Given the risk of methane accumulations on longwall faces, the ventilation of such systems must be constantly maintained. The extent of roof caving behind the shields is an important consideration for maintaining adequate longwall face ventilation. Air exchanges between the face area and gob of a longwall operation have been documented for different ventilation systems in several mines, but there are no substantial data available on caving characteristics and caving's impact on ventilation systems.

Method

NIOSH researchers employed a physical modeling approach to study the potential impact of caving on longwall face ventilation. Physical modeling also offers the advantage of simulating the performance of a ventilation system under controlled conditions. The LIAM is a 1:30 scale model geometrically designed to simulate a single longwall panel with a three-entry headgate and tailgate configuration (Fig. 1). For quantification of ventilation parameters such as velocity, pressure and temperature, the LIAM is equipped with hotwire anemometers, differential pressure sensors and thermocouples. In addition to the data from the sensors, all tests are recorded for visualization of airflow patterns using theatrical smoke in the LIAM.

Tests

The tests' objectives were to measure the air velocities within the gob and to determine the gob-face interaction and movement of air for longwall panels with different caving characteristics. Bleeder and bleederless ventilation systems were tested for different caving characteristics. Four caving scenarios were simulated: (1) no void space behind the shields, (2) six inches of void space, simulating 4.57 m (15 ft) in full scale, (3) 12 inches of void space, simulating 9.14 m (30 ft) in full scale, and (4) a rarer scenario with 18 inches of void space, simulating 13.7 m (45 ft) in full scale.

Results and discussion

In a normal caving scenario, where the roof caved right up to the shields, the following observations were made. Airflow was highly turbulent on the face, and airflow streams were formed in the gob. In the bleeder configuration, air traveled along the length of the face from the headgate to

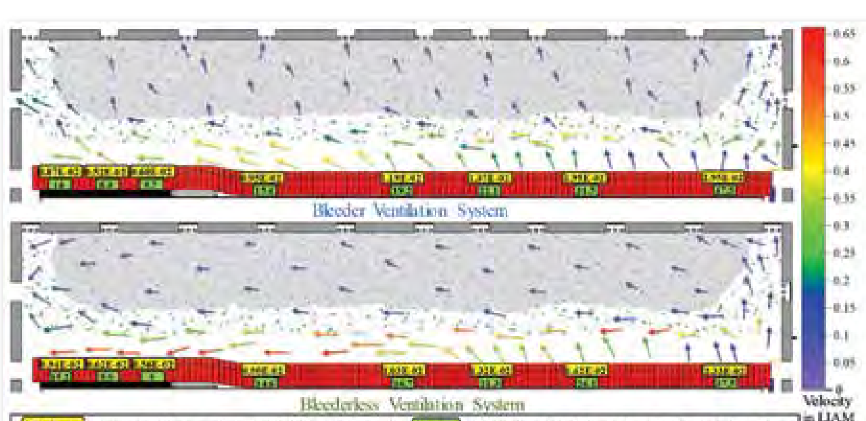

Fig. 2 Schematic showing airflow patterns in gob for the scenario with 9.14 m of void space.

tailgate side, with some air traveling right behind the shield line. On the face, part of the air enters the gob in front of the shearer (path of least resistance) and comes back on the face inby the shearer. For the flow in the gob, air enters the shield legs on the headgate side of the face and travels from the front of the gob toward the back bleeder entries. In the bleederless configuration, air traveled along the length of the face from the headgate to the tailgate. Similar to the bleeder system, a portion of air traveled behind the shield line. However, both the data and smoke visualization showed that in this case, some air came back on the face near the mid-face region. A similar phenomenon of more than one pathway of air and movement from the gob to the face has also been observed in a recent field study we conducted [2]. Such movement of air in the gob's void space may have severe mine safety implications, as the coalbed methane can get mixed with air and come back on the face on the tailgate side.

As the void space behind the shields increases, airflow on the face decreased and airflow in the gob increased significantly. For 4.57 m (15 ft) of void space behind the shields, airflow decreased on the face for both bleeder and bleederless scenarios. In addition, velocities as high as 0.85 m/s (167 fpm) were recorded in the gob. For 9.14 m (30 ft) of void space, the airflow on the face decreased further, leading to very low air quantities on the tailgate side of the face. The air velocities recorded in the gob were 0.31 to 0.41 m/s (60 to 80 fpm) for the bleeder configuration and 0.61 m/s (120 fpm) for the bleederless configuration (Fig. 2). In the rare scenario with 13.7 m (45 ft) of void space behind the shields, a major portion of the airflow moved into the gob from the face. In this case, for both ventilation configurations, there was a high degree of air recirculation and eddy formation in the gob. The results suggest that if there is a large volume of void space behind the shields, it can be very difficult to ventilate the face with either a bleeder or bleederless ventilation system. The air leakage from the face through the shields is pronounced, and the void space creates a low-resistance pathway of flow that can potentially cause both gas and spontaneous combustion problems. The study showed that caving characteristics have a significant impact on the ventilation of a longwall panel. ■

Disclaimer

The findings and conclusions in this paper are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention. Mention of any company or product does not constitute endorsement by NIOSH.

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Performance of a new fan silencer prototype for auxiliary ventilation

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Keywords: Health, Safety, Mine ventilation, Auxiliary fan, Noise-induced hearing loss (NIHL)

To read the full text of this paper (free for SME members), see the beginning of this section for step-by-step instructions.

Special Extended Abstract

Noise-induced hearing loss (NIHL) is prevalent in mechanized underground mines. Federal regulations are often not complied with effectively. Miners are also prone to ignoring administrative guidelines and/or personal protective equipment for hearing conservation. As a result, quality of life among experienced miners plummets while occupational risks increase at workplaces. This research focused on auxiliary fans used in underground mines. These fans work at high rotational speed and generate extremely high levels of noise in close proximity to miners. Silencers used are often of little effect due to poor maintenance. A new silencer is tried in the laboratory with the objective of easy maintenance and resulting reduction of noise exposure for miners.

Background

Sound levels in active underground mine workings us-