

MME Extended Abstracts

Sometimes, rock dusters are added at the discharge end to dust the roof, ribs and floor.

Laboratory model at the University of Utah

An auxiliary ventilation system model was set up in exhaust configuration. The system includes a 7.5-kW axial flow fan, a silencer, 0.51-m-diameter ductwork and a damper. The fan is installed with a fiberglass ductwork attached to its inlet and a ring-style silencer at its outlet. The inlet is equipped with a damper to simulate ducts of longer length and a variable-frequency drive to change the fan speed between 0 and 1,800 rpm (60 Hz).

The laboratory model included a prototype silencer consisting of two sections: a modified ring-style silencer and a re-packable silencer in which the sound-absorbing material can be retrieved and replaced (Fig. 1). The auxiliary ventilation system model was tested at the maximum fan speed of 1,800 rpm with the inlet duct damper wide open. Then, the tests were repeated after the damper cross-sectional area was reduced by 25-percent increments to simulate longer ducts. The testing setup and sampling points are shown in Fig. 2.

Four cases of fan performance and sound attenuation tests are presented: (1) fan system without silencer or extension, (2) fan system with a new ring-style silencer and extension with ProRox SL960, (3) fan system with a new ring-style silencer and extension with ROXUL AFB and (4) fan system with a new ring-style silencer and extension with ROXUL CR 80. Insulation material in the ring-style silencer itself was unchanged (SL960).

Analysis of results

Figure 3 shows a comparison of average sound levels for the four tests presented in this study. These were developed based on average sound levels. Based on this figure, it can be concluded that utilization of these silencers reduced the noise level by about 7 dB(A) at station 1, near the system inlet, and by about 14 dB(A) at station 7, at the system discharge. A close look at the histograms shows that the silencer with SL 960 insulation material provides better protection than the other materials.

Figure 4 shows sound-level histograms for the last three tests when the sound-level monitor was held at station 7. Based on these histograms it can be concluded that the three insulation materials have practically the same noise-absorbing characteristics. A closer look, however, shows that CR 80 outperforms the other materials in the low frequency bands. Figure 4 also shows the equivalent sound levels in dB(A) for the frequencies at which humans can hear the best. A comparison of sound levels in the 4,000 to 8,000 Hz range (red box) reveals that SL 960 outperforms AFB and CR 80 by about 2 dB(A).

Among other findings, this study found that, compared to the base case (test 1), utilization of the ring-style silencers reduced the fan capacity by about 5 percent and increased the fan pressure by about 8 percent, regardless of the type of material used. This is explained by the additional resistance to airflow caused by the pod-type silencers. ■

References

A list of references is available in the full article.

Evaluation of post-blast re-entry times based on gas monitoring of return air

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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

Blasting is the main method of production in many non-coal underground mining operations, producing multiple toxic gases. The U.S. Mine Safety and Health Administration (MSHA) requires mine operators to measure the level of toxic gases in mines as frequently as necessary to ensure they are

below regulatory safety limits. The current practice uses portable gas monitors to check the concentrations of toxic gases after a fixed post-blast time. This paper studies the application of a gas-monitoring system in the return entry of a limestone mine to determine a safe re-entry time. The study shows that

the use of gas monitoring in the return air can be a useful tool at the mine operator's disposal to detect and reduce the risk of hazardous conditions and also to reliably estimate the re-entry time.

Background

Production blasting operations using explosives in underground mines are a source of multiple toxic gases that could be harmful and even fatal to humans if prolonged exposure occurs beyond the safe limits. Continuous gas monitoring in the return air is an effective way to make sure that toxic gas concentrations at the working areas are kept below the regulatory limits before the return of miners.

In this study, a theoretical advection-dispersion transport model was used to examine the effects of measurement distance from the blasting face and the effective dispersion coefficient on the gas concentrations. Results from a multiple-gas monitoring study were presented and discussed. The collected gas data were used to calibrate the theoretical model and to predict the appropriate re-entry time after blasting.

Methods

The prediction model for contaminant concentration in a straight, long pipe at any distance from the source and any time was originally developed by Taylor [1] and is known as the one-dimensional advection-diffusion transport model. Other researchers [2-4] adapted it to develop predictive models for the spread of blasting fumes. The adapted model is given as follows:

$$C(x, t) = \frac{V}{2A\sqrt{\pi Dt}} \exp\left(\frac{-(x - \bar{u}t)^2}{4Dt}\right)$$

where x is the distance from the source in meters, t is the time from the release of contaminant in seconds, D is the effective axial dispersion coefficient in square meters per second, \bar{u} is average bulk air velocity in meters per second, A is the entry cross-sectional area in square meters, and V is the volume of gas at the source and beginning of time, $x = 0$ and $t = 0$, in cubic meters.

The U.S. National Institute for Occupational Safety and Health (NIOSH) conducted a monitoring program to measure multiple levels of post-blast toxic gases of interest — carbon monoxide (CO), nitric oxide (NO) and nitrogen dioxide (NO₂) — as well as the performance of other atmospheric-monitoring-system sensors for smoke, air velocity, oxygen and carbon dioxide in a partner limestone mine as part of ongoing research on sensor deployment strategies. The mine is using the room-and-pillar method to extract ore with a multiple face blasting operation working on a two, 12-hour shift schedule. The blasting operation takes place between the shifts to minimize the exposure risk hazard to toxic gases and to minimize delay by giving more time for the blasting gases to clear the mine.

Results and discussions

CO concentration curves from all days of blasting were averaged. One standard deviation puts the re-entry time at about 2.7 hours after each blast. The results suggest that the NO concentration is primarily below the threshold limit value (TLV) limit and returns to preblasting background level about two to three hours after blasting. Similar observations

and conclusions can be made from the NO₂ concentration curves. It can be observed that NO₂-measurement-based re-entry times are somewhat smaller (1.0 and 1.8 hours) compared to the ones based on CO gas. CO gas concentration curves demonstrate a slower decline, which is believed to be attributed primarily to the larger volume of CO gas and also possibly by the gradual generation of CO from diesel-powered equipment as well as the liberation of blasting fumes trapped in the muck pile that enter into the return air. The data show that CO is indeed the most critical gas, as it takes the longest time to clear the mine.

The calibrated model of each concentration curve and a corresponding TLV value, 25 ppm for CO, can now be used to estimate the re-entry time for each corresponding blasting operation. The re-entry time values for all 182 useful CO concentration curves out of 265 blasting events exceeding the TLV value of 25 ppm were determined from both measured and predicted concentration curves, referred to as measured and predicted re-entry time, respectively. Comparing the two re-entry time values shows an excellent agreement and correlation between the measurement and model-based re-entry time values.

Conclusions

This work supports NIOSH efforts to develop workplace solutions to improve detection of hazardous conditions. A monitoring system of selected multi-gas sensors was applied to an operating limestone mine to study the spread of toxic gases after blasting and to evaluate re-entry times. The measurement of blasting gases proved to be reliable and effective for real-time monitoring purposes in an operating mine with a complex ventilation network in a room-and-pillar mining operation.

The collected gas data show that CO takes the longest time to clear the mine compared to NO and NO₂. The re-entry time based on CO measurement was found to be 1.3 hours on average, 2.7 hours for one standard deviation, and well over three hours on some occasions.

The collected data were used to calibrate a theoretical one-dimensional advection-dispersion contaminant transport model. Excellent agreement between the calibrated model and measured CO concentration data confirms the validity of the simple one-dimensional model and its successful application to a complex ventilation network.

The developed model in this study helps the underground mine operators minimize the health hazard to the miners by predicting a safe re-entry time using real-time gas monitoring. However, the model should be used with caution by adding 10 percent or more to the predicted re-entry time values.

The calibrated model parameters are specific to the selected site, and further research will be needed to examine the applicability of the predictive model and improve the understanding of contaminant gas transport in underground mines with complex networks and large cross sections. ■

Disclaimer

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention.

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Evaluation of roof bolter canopy air curtain effects on airflow and dust dispersion in an entry using blowing curtain ventilation

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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

Roof bolter operators may be exposed to high respirable dust concentrations on continuous miner sections with blowing face ventilation when bolting is performed downwind of the continuous miner. One solution to reduce the high respirable dust concentrations is to use a canopy air curtain (CAC) to deliver clean air from a filtered blower fan directly to the bolter operators under the canopies. The influence of CAC installation on the airflow and dust dispersion around the location of the roof bolter operator can be evaluated by using computational fluid dynamics (CFD).

This study, performed by the U.S. National Institute for Occupational Safety and Health (NIOSH), considers two scenarios: (1) a roof bolting machine in the center of the entry for installation of the fifth row of bolts from the face, and (2) a roof bolting machine positioned close to the face for the installation of the last row of bolts. In both scenarios, the bolting machine is placed in an environment which contains 6.0 mg/m³ of respirable dust and is ventilated by a blowing curtain with 1.42 m³/s (3,000 cfm) of air. This environment is used to simulate the roof bolter machine operating downstream of a continuous mining machine. Two operation positions are simulated at the same bolting location: dual drill heads in the inward position for two inside bolts; and dual drill heads in the outward position for two outside bolts. The influence of the CAC on airflows and dust dispersion is evaluated with the CAC operating at 0.12 m³/s (250 cfm).

Introduction

The dust sources for roof bolting operation include (1) insufficient maintenance of the roof bolter dust collection system, (2) improper cleaning of the dust collection system and (3) working downwind of the continuous miner. The research interest of this study is the third dust source: the dust problems once the bolting machine is working downwind of a continuous miner or other dust activities.

To reduce the overexposure of respirable dust from upstream working activities, the use of CAC systems can be an engineering control solution. The CAC uses a blower fan with a filtered intake to deliver clean air to a mine worker. Since it is difficult to conduct experiments in the working face of an underground coal mine or even in the laboratory due to harsh environmental conditions, tight production schedules, and high experiment costs, computer simulation using CFD is used in this study to assess airflows and dust concentrations surrounding the roof bolter equipped with a CAC system.

Four simulation cases

Figure 1 shows a working face with a dual-head roof bolting machine at two locations. Figures 1a and 1b demonstrate a scenario in which the bolting machine begins to drill and bolt the outside or inside two holes at approximately 6.1 m (20 ft) from the face. The curtain setback is 9.1 m (30 ft)