

MME Extended Abstracts

its are given to mine operations, and there is no going back. The cost of sending low-grade material to the mill is significant. The lost opportunity of sending ore to a waste dump is also consequential. A trained professional could digitize dig limits, but it would be challenging to do this consistently, allowing some dilution and lost ore to achieve mineable shapes.

Method

The concept of using a rectangular floating selection frame for classifying mined material is considered to incorporate equipment constraints. The objective function is to minimize the cost of misclassification while ensuring that every high-resolution location is assigned to a floating selection frame. A multistage heuristic optimization algorithm is developed. An initial classification considers a fixed nonoverlapping configuration of selection frames. Problematic locations are visited and eliminated to obtain a feasible solution. The maximum-profit-feasible solution among all possible fixes is kept. A final hill climbing step is performed. Every location of the feasible solution is visited at random and perturbed. The perturbation is accepted if the change is feasible and the total expected profit increases. This last step is repeated several times with a different random path.

Results and discussion

This algorithm is heuristic and designed to minimize the difference between the profit achieved within the chosen dig limits and the profit achieved with free selection. There is no guarantee of optimality. This is considered a limitation, but also a practical advantage. Results are obtained quickly, and it is possible to visually and quantitatively assess how the

free selection case is modified to be considered more practical for the mining constraints.

Many examples have been considered. The paper shows two (Fig. 1). The top row in Fig. 1 shows blasthole locations colored by two grade variables that both contribute to the profit calculation in this real example. The bottom row shows the free selection optimum destination on the left and the results of our algorithm on the right with a five by five selection frame. In this case, the deemed mineable dig limits retain 98.8 percent of the maximum possible free selection profit. The optimization took 15 seconds.

Conclusions

The algorithm is designed to work as part of a comprehensive grade control system covering spatial prediction, blast movement modeling and selection optimization. We are convinced that multiple realizations of grade should be used to obtain expected profit values at each location of a discretized preblast mine bench. The realizations should honor multivariate relationships between grades and local geological features. Optimal final destinations for mined rock should be determined on a post-blast muckpile. Therefore, it is necessary to model blast-induced displacement of the discretized expected profit units. After the first two operations are performed, the optimal destinations for the mined material should be determined using post-blast expected profit with respect to excavating constraints. This paper presents details on the last component of an automatic grade control system. ■

References

A list of references is available in the full article.

Influence of trailing cables on magnetic proximity detection systems

Chenming Zhou*, Jingcheng Li, Nicholas Damiano, Jacob Carr and James Noll

CDC NIOSH, Pittsburgh, PA, USA

*Corresponding author emails: czhou@cdc.gov, JLi16@cdc.gov, ndamiano@cdc.gov, jcarr1@cdc.gov, jnoll@cdc.gov

Full-text paper:

Mining, Metallurgy & Exploration (2019) 36:277–284, <https://doi.org/10.1007/s42461-019-0047-9>

Keywords: Proximity detection systems, Magnetic field, Parasitic coupling

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

Machine-related injuries are a major safety concern in underground coal mines. Severe injuries and fatalities can occur when a miner is struck, crushed or pinned by mining equipment, such as a continuous mining machine, shuttle car or scoop. Proximity detection systems (PDSs) have been used

in mining to reduce these types of injuries and fatalities. All of the PDSs that are currently approved by the U.S. Mine Safety and Health Administration (MSHA) for use in underground coal mines are magnetic-field-based and could be affected by metallic objects such as trailing cables. Researchers from the

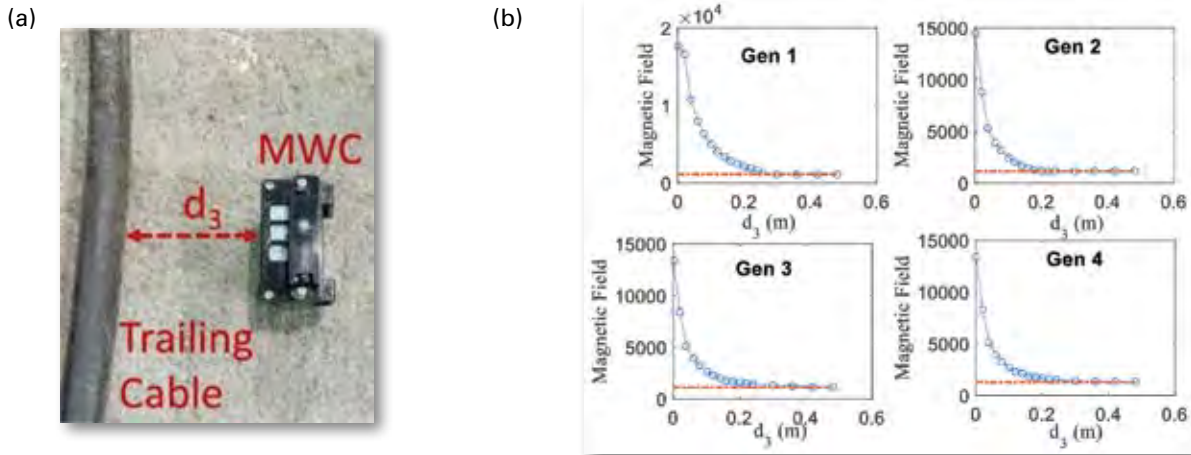


Fig. 1 (a) The magnetic field coupled from a proximity detection system to a trailing cable is measured by a miner-wearable component for different separation distances between the miner-wearable component and the trailing cable. (b) Magnetic field strength measured by a miner-wearable component decreases with the distance between the miner-wearable component and the trailing cable.

U.S. National Institute for Occupational Safety and Health (NIOSH) investigated the influence of trailing cables on the performance of PDSs. In particular, the magnetic field coupled from proximity system generators to a de-energized trailing cable was characterized. The results show that significant energy can be coupled from the proximity detection system generators to a trailing cable when there is a closed loop in the cable. The effect on PDS performance from the magnetic field radiated around an energized trailing cable was also quantified for different current amplitudes in the cable. It was shown that the magnetic field caused by the electric current in the trailing cable mainly consists of a 60-Hz signal and its harmonics, which cause little interference to the PDS. The results presented in this paper can help PDS manufacturers to design better systems that are more immune to these effects.

Background

Due to the limited space and visibility underground, miners working near large mining machines, such as continuous mining machines, often face pinning, crushing and striking hazards that may result in accidents involving life-threatening injuries and death. In response to these hazards, MSHA promulgated a regulation in 2015 requiring the use of a PDS on all continuous mining machines except full-face machines [1] and proposed a regulation that would require a PDS on other mobile underground equipment [2]. Current PDSs approved for underground use are magnetic-field-based. The magnetic PDS consists of machine-mounted magnetic field generators that create fields around the machine, and a miner-wearable component that reads the flux density fields created by the generators. These systems use the magnetic field strength readings from the miner-wearable component to determine whether a miner is at a safe distance from the machine. A stable magnetic field is essential for the accuracy of the system.

While PDSs are effective in protecting mine workers from pinning, crushing and striking hazards, they can produce false alarms under certain conditions. Particularly, field observations have shown that the presence of trailing cables

could significantly affect the performance and accuracy of the systems. Theoretically, trailing cables can affect the performance of magnetic PDSs through two mechanisms: passive coupling and active interference. This paper discusses the experiments that were designed to investigate the effect of these two mechanisms.

Key results

The measurement results confirmed that the presence of a trailing cable can significantly enhance the magnetic field received by a miner-wearable component, due to the parasitic coupling from the PDS to the trailing cable. It was also found that the coupled magnetic field is highly dependent on the distance between the miner-wearable component and the trailing cable (Fig. 1). As shown in Fig. 2, the coupled magnetic field decreases exponentially with this distance. As a result, the parasitic coupling from a PDS to a trailing cable can be mitigated by maintaining a minimum separation distance — for example, 20 cm for this specific case — between the miner-wearable component and the cable. Another test was conducted to evaluate the influence of a ground loop on the coupling effect. It was found that the ground loop facilitates the coupling and thus should be avoided.

For the second mechanism, the active magnetic field radiated from an energized trailing cable was measured under different current conditions, and the results show that the magnetic field generated by a high electric current in a trailing cable produces a strong 60-Hz signal and its harmonics, but has little impact on the performance of the PDS. One scenario that has not been fully tested is the influence of the noise coupled or conducted from the mining equipment to the trailing cable. In the energized trailing cable test reported in this paper, the load of the trailing cable was a forced-air cooled resistor bank that does not generate low-frequency noise, as is generated by typical mining equipment. In addition, the resistor load produces a constant current while the current drawn by mining equipment would vary with time.

This paper contributes to the safety of mine workers by providing a research foundation from which recommenda-

tions and guidance may be developed to ensure proximity detection systems work properly in the presence of trailing cables. It is anticipated that the results and findings in the paper will be applicable to all magnetic PDSs that operate in a frequency close to 70 kHz. ■

Disclaimer

The findings and conclusions in this report are those of the authors and do not necessarily represent the views of

the National Institute for Occupational Safety and Health. Reference to specific brand names does not imply endorsement by NIOSH.

References

1. Mine Safety and Health Administration (2015), U.S. Department of Labor, Proximity detection systems for continuous mining machines in underground coal mines, Fed Regist 80(10):2189-2203, Jan.15, 2015.
2. Mine Safety and Health Administration (2015), U.S. Department of Labor, Proximity detection systems for mobile machines in underground coal mines, Fed Regist 80(170):53070-53086, Sept. 2, 2015.

Comparing the implementation of two dust control technologies from a sociotechnical systems perspective

Emily J. Haas*, Andrew B. Cecala and Jay F. Colinet

Pittsburgh Mining Research Division, National Institute for Occupational Safety and Health, Pittsburgh, PA, USA

*Corresponding author email: EJHaas@cdc.gov

Full-text paper:

Mining, Metallurgy & Exploration, <https://doi.org/10.1007/s42461-019-0063-9>

Keywords: Communication, Dust monitoring technology, Organizational interventions, Respirable dust, Socio-technical system

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

Researchers from the U.S. National Institute for Occupational Health and Safety (NIOSH) studied the impact of an unregulated dust control technology (the Helmet-CAM) and a regulated dust control technology (the continuous personal dust monitor) within a sociotechnical system (STS) framework to mitigate respirable dust sources. The results address how to best incorporate the overarching principles of meta-design STS during the technology integration process. Specifically, quantitative and qualitative data show that a prominent focus on the social factors within an STS framework could help reduce organizational unpredictability and may improve communication within the system to help reduce technology adoption time.

Introduction

Arguments placing communication as critical during any technology integration have put a focus on the social factors within meta-design STSs [1]. One assumption of meta-design is that future problems cannot always be predicted, and that if users become “co-designers” during development and implementation, then the system’s boundaries can be extended to support the needs of workers, workgroups and the organization [2]. Therefore, the principles of meta-design facilitate action-research that can help improve worker and organizational performance [3, 4].

Methods

The roles of dust exposure regulation in mining (environment), dust assessment technologies (technical), and worker awareness and performance along with management implementation and support (social) are not completely clear, nor can a standardized approach exist to ensure that the organizational system remains intact during technology implementation. Specific to respirable dust control in the mining industry, several engineering controls have been identified, developed and implemented [5,6], but many engineering solutions can be better integrated with the organization and workers [7].

This paper sought to extend STS in mining through applying principles of meta-design to analyze the results of two case study interventions. We examined the impact of an unregulated dust control technology (the Helmet-CAM) and a regulated dust control technology (the continuous personal dust monitor (CPDM)) on employees’ knowledge of, communication about, and maintenance of dust-reducing work practices within their mine organization. The first case study with the Helmet-CAM involved 48 miners and 17 managers from five industrial mineral mines. The second case study with the CPDM involved 35 miners and 15 managers from three underground coal mines. For both case studies, a convenient, purposive sampling strategy was used to recruit

Reproduced with permission of copyright owner. Further reproduction prohibited without permission.