cesses on the industrial scale. This relation has been used as a kinetic curve to estimate the overall metal extraction in a heap-leaching process.

However, the wide use of this equation has tended to forget its origin and constraints. The LR has been extremely helpful for heap-leaching operations, but a new revision or approach, particularly for complex ores, could be studied and developed in order to enhance the successful performance of this unit operation. ■

Selected references

1. Petersen J (2016) Heap leaching as a key technology for recovery of values from low-grade ores – A brief overview. Hydrometallurgy 165:206–212
2. Ghorbani Y, Franzidis JP, Petersen J (2016) Heap leaching technology – current state, innovations and future directions: a review. Min Proc Ext Met Rev 37(2)73–119
3. van Staden PJ, Kolesnikov AV, Petersen J (2017) Comparative assessment of heap leach production data – 1. A procedure for deriving the batch leach curve. Miner Eng 101:47–57
4. van Staden PJ, Huynh TD, Kiel MK, Clark RI, Petersen J (2017) Comparative assessment of heap leach production data – 2. Heap leaching kinetics of Kipoi HMS floats material, laboratory vs. commercial scale. Miner Eng 101:58–70

Investigation of machine-mounted area lighting to lower injury risk from slips-trips-falls for operators of mobile surface mining equipment

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Keywords: Surface mining equipment, Machine-mounted lighting, Slips-trips-falls, Glare, Ingress/egress systems

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

During dusk, nighttime and dawn operations, effective illumination is a crucial component of safety for getting on/off mobile surface mining equipment and for preshift inspections. U.S. National Institute for Occupational Safety and Health (NIOSH) researchers examined whether illuminance levels could be improved for ingress/egress systems and preshift walkaround inspections of equipment using light-emitting diode (LED) area luminaires. Illumination and glare were key metrics evaluated. Although headlamps provided adequate illumination, LED area luminaires illuminated a much broader area compared to the narrow spot lighting of the headlamp. Hence, the use of additional area luminaires can increase slip-trip-fall (STF) hazard awareness and detection. Furthermore, a commercially available luminaire demonstrated better results than a custom LED luminaire relative to discomfort and disability glare.

Introduction

Injury/illness data from the U.S. Mine Safety and Health Administration (MSHA) show that slips, trips or falls are the second leading cause of nonfatal incidents. Insufficient or ineffective lighting is a factor associated with nonfatal incidents and injuries [1]. Mobile-equipment operator is among the most common surface mine worker occupations associated with nonfatal incidents reported to MSHA [2]. Mobile-equipment operators in the surface mining industry are routinely exposed to STF hazards. Getting on/off the equipment (ingress/egress) contributes frequently to the highest number of nonfatal incidents. Furthermore, results of a recent study revealed that mobile-equipment operators believed proper illumination is an important element of safety for ingress/egress systems [3].

Previously, Mayton and Nasarwanji [4] examined illuminance levels on and about mobile surface mining equipment and their ingress/egress systems. They noted that illuminance levels were inadequate compared to levels recommended by the Illuminating Engineering Society (IES) [5,6]. Subsequently, the objectives of the present study are to: (1) assess whether illuminance levels could be improved for ingress/egress systems and preshift walkaround inspections of equipment and (2) compare illuminance and glare levels for two LED area luminaires.

Methods

During a field study at a surface limestone mine in northwestern Pennsylvania, researchers from NIOSH collected photometric and related data on and about two haul trucks and two wheel loaders. Two commercially available area luminaires from Mr. Beams (luminaire-1) and Saturn (luminaire-2) were mounted on the equipment and used to augment the LED headlamp provided by the mine operator. Luminaire 2 was previously investigated on an underground coal mine roof bolting machine [7-9] as a custom-designed, custom-built light source with an LED array.

Task illuminances collected using a photometer and a reflectance standard [10] were compared to IES-recommended levels. A quantitative mathematical method [11] was used to predict the De Boer subjective rating of discomfort glare [12].

Finally, disability glare from the luminaire sources was determined by calculating veiling luminance. Disability glare indicates the extent of glare related to contrast reduction in the scene viewed, which can influence hazard detection. Measurements were taken on and around the mobile equipment for the ingress/egress system and preshift, walkaround inspection.

Results and discussion

Measured illuminances of visual tasks, with the headlamp alone and with the area luminaires plus the headlamp, revealed that illuminances met or exceeded IES-recommended levels (Fig. 1). During data collection, the presence of 2- to 4-in. or greater ruts were noted in the ground surface created by tire treads that are most pronounced after a rainfall that causes muddy operating conditions. An awareness and discernment of these hazards are critical to detecting and avoiding STF injury risk and not possible with the limiting spot lighting from the headlamp. The area luminaires illuminated a much broader area (Fig. 2) as compared to the headlamp alone, thereby increasing the likelihood of detecting these STF hazards.

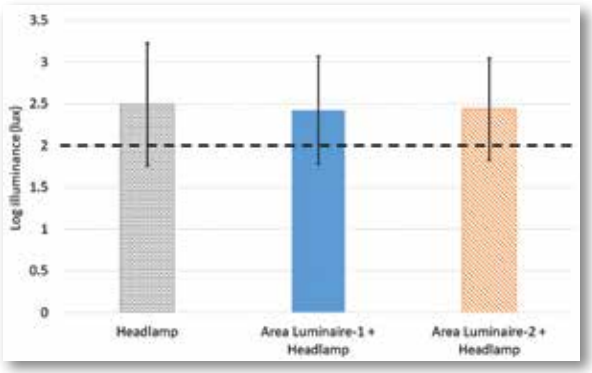

Fig. 1 Log task illuminance using the RS-3 reflectance standard for all ingress/egress and preshift walkaround tasks using the headlamp and the two area luminaires. The dashed line indicates the IES-recommended illuminance level.

Discomfort and disability glare were less with luminaire-1 than with luminaire-2. Differences in glare were more noticeable for newer models of haul trucks and loaders featuring updated designs in ingress/egress systems. The location and placement of the area luminaires are critical in improving illuminance levels on the ingress/egress systems, and the ground surfaces for the walkaround inspections, and would need to be customized for mobile equipment.

Conclusions

This study demonstrates that although headlamps provide adequate illumination, commercially available luminaires such as luminaire-1 are capable of complementing headlamp lighting. Using additional area luminaries can increase STF hazard awareness and detection during ingress/egress and preshift inspection tasks. ■

Disclaimer

The findings and conclusions in this paper are those of the authors and do not necessarily represent the official views of NIOSH. Mention of any company or product does not constitute endorsement by NIOSH.

Selected references

1. Nasarwanji MF, Pollard J, Porter, W (2018) An analysis of injuries to front-end loader operators during ingress and egress. Int J Ind Ergon 65:84–92
2. Mine Safety and Health Administration (2015-2017) Mining industry accident, injuries, employment, and production statistics and reports
3. Pollard J, Kosmoski C, Porter W, Kocher L, Whitson A, Nasarwanji MF (2019) Operators' views of mobile equipment ingress and egress safety. Int J Ind Ergon 72:272–280
4. Mayton AG, Nasarwanji MF (2020) Let There Be Light. Pit & Quarry, February, pp. 100, 102, 104
5. Kaufman JE (ed) (1981) IES Lighting Handbook, Application Volume, pp. 2–5, 2–14, Illuminating Engineering Society (IES), New York, NY
6. DiLaura DL, Houser KW, Mistrick RG, Steffy GR (eds) (2011). The Lighting Handbook, 10th edition, Reference and Application, Illuminating Engineering Society (IES), New York, NY
7. Sammarco JJ (2018) NIOSH Saturn Area Light (available from webpage in full paper)
8. Sammarco JJ, Macdonald BD, Demich B, Rubenstein, EN, Martell MM (2018) LED lighting for improving trip object detection for a walk-thru roof bolter. Lighting Research & Technology, pp. 1–17
9. Sammarco JJ, Mayton AG, Rubenstein EN (2020) LED area lighting to reduce glare for roof bolter operators. Mining, Metallurgy & Exploration 37:851–860

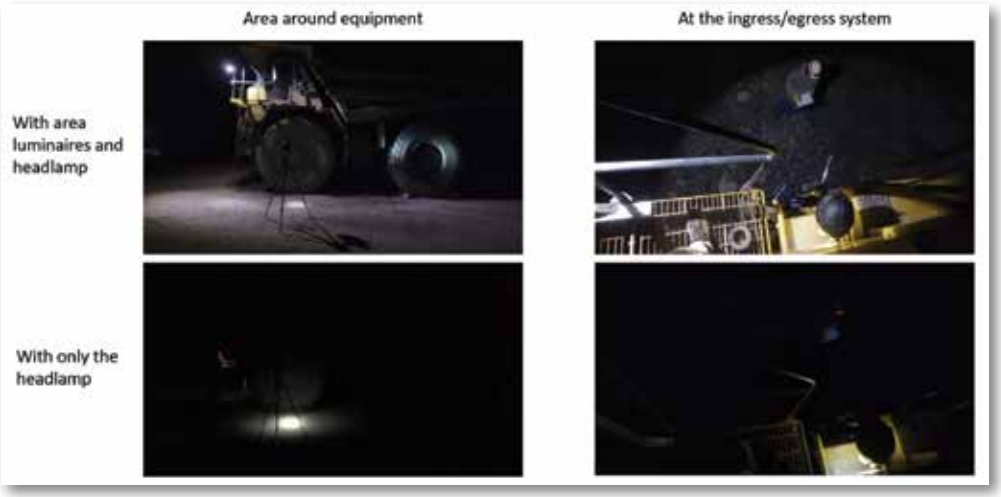

Fig. 2 Comparison of the area illuminated using the LED area lighting plus the headlamp (top left and right images) versus the headlamp only (bottom left and right images). The scenes depicted are at ground level on the driver's side of the equipment (left images) and at the top platform of the ingress/egress system (right images).

10. Mayton AG (1991) Investigation of task illumination for surface coal mining equipment operators. Journal of the Illuminating Engineering Society 20(1):2–18
11. Bullough JD, Brons JA, Qi R, Rea MS (2008) Predicting discomfort glare from outdoor lighting installations. Lighting Research & Technology 40(3):225–242
12. De Boer JB (1967) Visual perception in road traffic and the field of vision of the motorist. Public Lighting. Philips Technical Library, Eindhoven, Netherlands, pp. 11–96

Use of ammonia salts in selective copper extraction from tailings

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Keywords: Copper, Extraction, Tailings, Leaching, Ammonia salts

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

Tailings, or flotation waste, formed during copper production may be considered in the class of valuable wastes because of the amount of copper they contain. With the decreasing grade values of copper ores, the utilization of wastes like tailings that carry certain amounts of copper as secondary sources has become a necessity in both the economic and environmental senses.

This study was carried out with the aim of using ammonium derivatives for the recovery of copper from tailings waste produced during copper production and utilizing their complex formation characteristics. In the conditions of six hours of leaching at 30 °C in the presence of 22.5 percent ammonium hydroxide and 100 g/L ammonium persulfate, 91.47 percent of the copper was transferred into the solution, while iron was not transferred, indicating that copper can be selectively recovered from tailings.

Summary

If copper is to be recovered by hydrometallurgical methods from secondary sources with low copper contents like tailings, a highly selective extraction process is desired. This brings the creation of alkaline leaching conditions to mind. For this purpose, this study examined the conditions of selective copper leachability with chemicals containing various ammonium derivatives.

The usage conditions of five ammonia salts – ammonium hydroxide (NH_4OH), ammonium carbonate ($(NH_4)_2CO_3$), ammonium nitrate (NH_4NO_3), ammonium chloride (NH_4Cl) and ammonium persulfate ($(NH_4)_2S_2O_8$) – as leaching reactants for the selective extraction of copper from tailings were investigated by examining the effects of parameters such as leaching temperature and leaching time at different concentrations of the salts.

The copper extraction efficiencies when the salts were used by themselves were found to be $(NH_4)_2CO_3$, 73 percent > $(NH_4)_2S_2O_8$, 69 percent > NH_4OH, 64 percent > NH_4Cl, 42 percent > NH_4NO_3, 40 percent. The highest copper extraction efficiencies were achieved with solutions obtained by mixing two ammonia salts in the optimum conditions. After six hours of leaching at 30 °C in the presence of 22.5 percent NH_4OH and 100 g/L $(NH_4)_2S_2O_8$, 91.47 percent of the copper was transferred into the solution, while iron was not transferred. The obtained results show that copper can be selectively recovered from tailings.

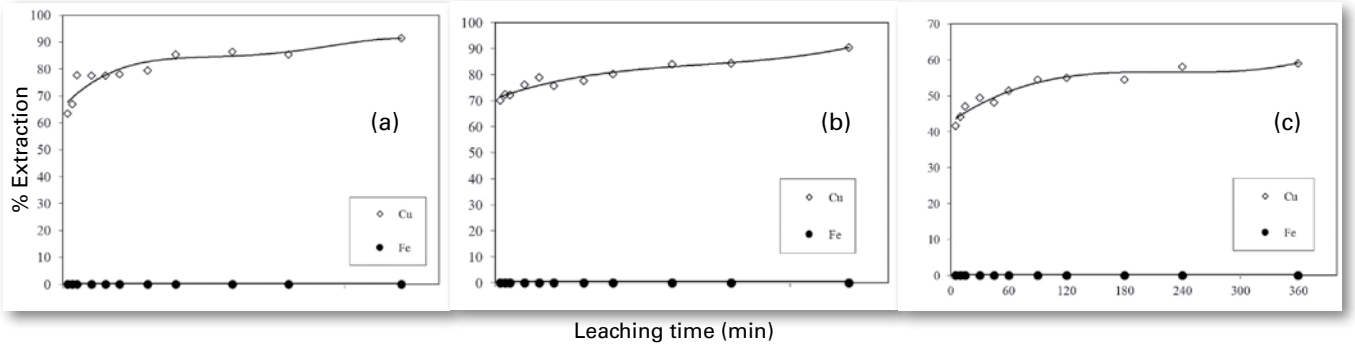

Fig. 1 Effect of leaching time on mixtures of NH_4OH-$(NH_4)_2S_2O_8$ and $(NH_4)_2CO_3$-$(NH_4)_2S_2O_8$: (a) 22.5 percent NH_4OH, 100 g/L $(NH_4)_2S_2O_8$, 30 ºC, (b) 22.5 percent NH_4OH, 200 g/L $(NH_4)_2S_2O_8$, 30 ºC and (c) 50 g/L $(NH_4)_2CO_3$, 100 g/L $(NH_4)_2S_2O_8$, 30 ºC.