10 times higher than in the salt flotation affects the Krafft point of the long-chain amines used as collector to float sylvite and further reduces solubility of this compound in the brine [1].

In the flotation of sulfide ores, such as nickel or copper ores, with xanthate-like collectors, the xanthate collector is apparently not affected by pulp ionic strength. Short-chain xanthates are highly soluble in water. The most visible difference between commercially utilized xanthates and other flotation surfactants is that only short-chain xanthates are utilized by industry while the ionic collectors used in the flotation of a large variety of minerals have alkyl chains of at least C12. These differences result from the fact that xanthate ions interact with sulfide surfaces by forming dixanthogen and heavy-metal xanthates, while for long-chain surfactants the most likely mechanism of adsorption proceeds via hemi-micelle formation on the mineral surface. Apparently the ionic strength of the pulp in the flotation of sulfides ores (Cu, Ni) with xanthate-like collectors does not affect recovery of the valuable metal, but the frothability of these systems is affected and so the dosage of frother is to be reduced.

The content of Mg^{2+} and Ca^{2+} ions in seawater is the main difference between such systems and fresh water. The presence of these metallic ions can adversely affect flotation in the pH ranges over which these ions hydrolyze. The successful flotation of copper–molybdenum (Cu–Mo) ores typically requires depression of pyrite at high pH values achieved with the use of lime. When the process is carried out in seawater, either removal of the hydrolysis products of Mg^{2+} and Ca^{2+} ions is required, or the use of a pyrite depressant that can be effective over the pH ranges that are much below the pH of hydrolysis. Mg^{2+} and Ca^{2+} ions also affect flotation of phosphate ores with fatty acids. In this case, the depression mechanism is not caused by precipitating magnesium hydroxides on the mineral surface but by precipitation of collector insoluble salts, and the same ions are responsible for depression in both cases. In the seawater flotation of Cu–Mo sulfide ores and phosphate ores, the practical solution involves either removal of Mg^{2+} and Ca^{2+} ions prior to the flotation or complexation of these ions with other reagents. ■

References

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Evaluation of different carbon monoxide sensors for battery charging stations

James H. Rowland*, Liming Yuan, Richard A. Thomas and Lihong Zhou
Pittsburgh Mining Research Division, National Institute for Occupational Safety and Health, Pittsburgh, PA, USA
*Corresponding author email: jlr5@cdc.gov

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Special Extended Abstract

Hydrogen (H_2) gas released during battery charging can result in cross-interference for carbon monoxide (CO) sensors used for early fire detection and compromise the integrity of the mine atmospheric monitoring system. In this study, a series of laboratory-scale and full-scale experiments were conducted to evaluate the responses of different CO sensors to H_2 gas. In the laboratory-scale experiments, H_2 concentrations in the airflow are constant, while in the full-scale experiments, increasing H_2 concentrations generated as a byproduct of charging the batteries at the battery charging station rise to the sensors under different ventilation scenarios. The H_2 concentrations at the CO sensor location were measured using H_2 sensors and were correlated with the CO sensor response. The effects of ventilation and sensor location on the CO sensors responses were also analyzed. The results of this study can help mining companies to select appropriate CO sensors and improve the deployment of these sensors to safeguard underground miners.

Background

Many types of battery-powered mining equipment such as scoops and shield haulers are used in underground mining operations, and charging stations are required to charge the equipment batteries. These batteries are of lead acid chemistry. A safety issue exists with the battery charging stations as all lead acid batteries produce flammable H_2 gas during the normal charging process. Overcharging or excessive heat can quickly cause batteries to produce even more H_2. If H_2 is not appropriately diluted or dispersed, it builds up, and the risk of fire and explosion increases. In practice, CO sensors are often installed in underground battery charging station areas to detect overheating or a fire through an atmospheric monitoring system system. To ensure early detection, it is imperative for CO sensors to function correctly, but CO sensors used in underground mines are of the electrochemical type, which can exhibit cross-interference with other gases. For the electrochemical CO sensors, one interfering gas is H_2. To overcome cross-interference from the H_2 that is released during the normal battery charging process for lead acid batteries, certain H_2-compensated CO sensors were developed, but they can only reduce the cross-interference to a certain extent, and some of these sensors may not function as well as expected. In this study, a comprehensive evaluation of CO sensors for battery charging stations was conducted to examine the responses of both normal CO sensors and H_2-compensated CO sensors to various H_2 concentrations.

Method

Laboratory-scale and full-scale experiments were conducted to evaluate the performance of different CO sensors under H_2 cross-interference. Seven commonly used CO sensors from five different manufacturers were tested: Rel-Tek, AMR H_2 compensated, Conspec, Pyott-Boone 1 (designated as PB 1) H_2 compensated, Pyott-Boone 2 (designated as PB 2), Strata 1 and Strata 2 H_2 compensated. All of these sensors are diffusion-type electrochemical sensors. All sensors are Mine Safety and Health Administration-approved for use in underground coal mines and were calibrated before each test.

For the laboratory-scale testing, a manifold was fabricated to connect all of the CO sensors together, and all sensors were exposed to the same airflow simultaneously. The calibration gas cylinder was connected to the manifold at both ends. A flow meter was used to measure the gas flow rate from the calibration gas cylinder. During the test, calibration gas of different H_2 concentrations — 100, 200 and 500 ppm — was applied into both ends of the manifold for eight minutes and 30 seconds at a flowrate of 500 mL/min until readouts were stable, then the gas was shut off. A data acquisition system was used to collect the data from each sensor during the test for further analysis.

The full-scale battery charging station testing of CO sensors was conducted in a battery house containing 48-cell, 96-V lead acid batteries and a charger previously used for an underground locomotive. There was a ventilation fan at the top side wall of the house and a louvered vent at the opposite top side wall to ventilate the battery house. All CO sensors were mounted on a frame 36 in. above the top of the batteries. Three H_2 sensors were installed above the batteries to measure the H_2 concentrations. One H_2 sensor was mounted at the same height as the CO sensors, and the other two were mounted at lower heights of 24 and 12 in., respectively. To investigate the factors that may influence the H_2 dilution, a 50 × 38 × 48 in. plywood enclosure was built around the batteries. The top of the enclosure was covered with plastic, and the coverage was changed in the tests to examine the effect of the top opening on the measured H_2 concentrations. The batteries were discharged overnight with a load center to ensure that the batteries would require a full charge before each sensor test.

Results

Laboratory-scale testing of the CO sensors was conducted using different H_2 concentrations in the airflow. A sensor response test was first conducted without H_2 but with 25 ppm CO in the airflow to examine the sensor response to the standard CO calibration gas using the testing apparatus. The Strata 1 sensor had the shortest response time of 30 s, while the PB 2 sensor had the longest response time of 120 s. The stable readings for all sensors after 10 min were not exactly 25 ppm. The lowest reading was 20 ppm, and the highest reading was 27 ppm. The CO sensors were exposed to 100, 200 and 500 ppm H_2 calibration gas in the airflow. As 10 ppm CO is commonly used as the threshold value for alarming in mine fire detection systems, this value is used as the criterion for determining if a CO sensor is affected by H_2 to the extent that a false alarm occurs. The AMR CO sensor was the only sensor that remained under the 10-ppm threshold for each calibration gas.

Full-scale testing of CO sensors was conducted using the battery charging station. When the CO sensors were tested with the enclosure top 100 percent open, the same results as the laboratory-scale testing were obtained, only the AMR sensor was not affected by the H_2 concentration. The seal battery enclosure was employed with the top 44, 72 and 100 percent open. As the enclosure opening increased, the time to reach 1,000 ppm H_2 increased from 20 min to 143 min. With the enclosure 100 percent open, only the AMR CO sensor was not affected. The worst case in a mine setting is no ventilation; there were no significant differences between H_2 concentrations with or without the enclosure open 100 percent. The CO sensors were placed 36, 64 and 70 in. above the battery. The PB 1, PB 2, Conspec and Rel-Tek sensors showed CO readings in excess of 10 ppm, while the AMR, Strata 1 and Strata 2 sensors were below this level at the 64-in. height. Only the AMR and Rel-Tek sensors after four hours at the 70-in. level showed responses less than 10 ppm.

Discussion

The laboratory-scale test results indicate that at 100 ppm H_2, three sensors — Conspec, Strata 2 and AMR — showed readings less than 10 ppm, an alarm threshold in mine fire detection systems. At 200 ppm H_2, two sensors — Conspec and AMR — produced readings less than 10 ppm, and at 500 ppm, only the AMR sensor exhibited this behavior. In full-scale tests without any ventilation, only the AMR sensor showed readings less than the threshold. This was consistent with the laboratory-scale test result at 500 ppm H_2 concentration. In the full-scale tests with ventilation, three sensors — PB1, Strata 2 and AMR — showed readings less than the alarm threshold. Sensor performance also varied with height above the recharging batteries. The ventilation airflow not only affected the H_2 concentration at the CO sensor location, but also affected the response of the CO sensor itself, as the CO sensors were diffusion-type electrochemical sensors.

Conclusion

Laboratory-scale and full-scale experiments were conducted to evaluate the responses of different CO sensors when exposed to H_2. These analyses assumed a 10 ppm alarm level for CO, where any CO sensor response to H_2 gas in excess of that would trigger a false alarm. The experimental results indicate that out of the seven CO sensors tested, only the AMR sensor was minimally affected in all laboratory-scale and full-scale tests. Except for the AMR sensor, the other two H_2-compensated CO sensors — PB 1 and Strata 2 — did not perform any better than non-H_2-compensated CO sensors. The actual quantities of H_2 released from the battery charging may vary greatly from battery to battery. The H_2 concentration in the vicinity of the batteries can be affected by the ventilation. In this study, H_2 concentrations exceeded 1,000 ppm when the batteries were not ventilated. With ventilation applied, H_2 concentration reached about 450 ppm. To overcome the cross-interference from H_2, it is important to select appropriate CO sensors that are minimally affected by the presence of H_2 and provide ventilation to dilute and remove accumulations of this gas to prevent false alarms and ensure the effectiveness of fire detection system for the battery charging stations. ■

Combined effect of operating parameters on separation efficiency and kinetics of copper flotation

Ataallah Bahrami[1], Yousef Ghorbani[2*], Mohammad Raouf Hosseini[3], Fatemeh Kazemi[1], Morteza Abdollahi[1] and Abolfazl Danesh[4]
[1]Department of Mining Engineering, Urmia University, Urmia, Iran
[2]Department of Civil, Environmental and Natural Resources Engineering, Luleå University of Technology, Luleå, Sweden
[3]Department of Mining Engineering, Isfahan University of Technology, Isfahan, Iran
[4]Mineral Processing Plant, Sungun Mine, Tabriz, Iran
*Corresponding author email: Yousef.Ghorbani@ltu.se

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Special Extended Abstract

This study aims to investigate the effects of the operational variables on the concentrate grade, recovery, separation efficiency and kinetic parameters of the copper flotation process. The results indicate that concentrate collecting time and pulp density were the parameters with the greatest effects on the concentrate grade. Considering copper recovery, the concentrate collecting time, collector dosage and pulp density were the most significant variables, in decreasing order of importance. The separation efficiency was found to be mainly influenced by the concentrate collecting time. This study can be helpful in identifying the parameters with the most effects on flotation performance and, consequently, the overall process efficiency, including recovery and separation efficiency. Such an outcome can be used as a decision-based tool to apply the necessary changes in a real-life industrial operation in a more effective way to improve the quality and quantity of the flotation concentration.

Introduction

Froth flotation is a physicochemical process that has been used for more than a century in the concentration of copper sulfide minerals. A very important aspect of flotation is its kinetics. This paper's aim is to evaluate the kinetics models and to investigate the influence of some control-