TECHNICAL PAPERS

Mine-shaft conveyance monitoring

Abstract

Monitoring conveyance position and wire rope load directly from the skip or cage top offers several significant safety and production advantages. The Spokane Research Laboratory of the National Institute for Occupational Safety and Health (NIOSH) developed a shaft conveyance monitoring system (SCMS). This system consists of position and guide-displacement sensors, a maintenance-free battery power supply and a new sensor, which is mounted on the wire rope with a Crosby Clip, to measure hoist-rope tension. A radio data link transmits sensor output to the hoistroom. A state-of-the-art automated hoisting test facility was also constructed to test the concept

Introduction

The shaft is the lifeline to underground mines. Miners depend on it for safe transport to and from the workplace and the efficient flow of materials. Hoisting accidents resulting in injury are uncommon, but all hoist accidents have the potential to be catastrophic. For example, in 1973 at the Markham Colliery in Derbyshire, UK, a conveyance overwound and fell to the pit bottom, resulting in 17 deaths. According to US Mine Safety and Health Administration (MSHA) data, many shaft-related accidents in the United States are associated with conditions related to the hoisting and loading-unloading cycle. One such condition, known as slack rope, is particularly dangerous, especially if it occurs without the operator's awareness. Causes of slack rope in metal and nonmetal mines are often ground-control or guide-alignment-related, which can cause the cage or skip to become obstructed. Other hazards are related to falls of miners and materials, ground instability and malfunction of safety devices, such as conveyance doors, etc. Figure 1 shows the number of shaft-related accidents by type in all underground mines from 1992 to 1996. These shaft-related accidents are based on a keyword search of MSHA narratives.

Hoist and elevator machinery must meet the requirements specified in the Code of Federal Regulations (CFR), Parts 57 and 75. In response to a request from MSHA to improve the safety of mine hoisting, researchers at the Spokane Research Laboratory (SRL) of NIOSH developed new technology for hoisting operations. The immediate goal of the research is to improve the shortcomings of existing safety controls, such as slack rope saglines, by increasing the quantity and quality of data related to the operation of mine hoists and to develop a means of warning miners about potentially dangerous situations.

and reported on monitoring and control systems and sensors for hoists and conveyances (Farley et al., 1983; Ward, 1993). In addition, there are several commercially available hoist-monitoring systems. These systems indirectly determine conveyance malfunctions or directly incorporate various conveyance-mounted sensors. They transmit data by inductive coupling to the hoist-rope, high-power microwave transmission up the shaft or by leaky feeder transmission cable.

Based on these investigations, SRL researchers determined that there are several shortcomings in hoist-monitoring technology. In particular, there is a lack of accurate measurement of wire rope tension and measurement of conveyance load and position. These are important precursors to impending stuck conveyance and slack rope. This paper describes a sensor and data-acquisition system to monitor mine-hoist conveyances. It also describes a research facility built to test these components.

Conveyance-mounted monitoring system

Development of a shaft conveyance-mounted monitoring system has focused on a maintenance-free, unobtrusive package for determining position, load, wire rope tension and guide displacement. Previous work (Beus et al., 1995) described initial concept development. The current work involves further development and refinement of the system through laboratory and field evaluations of sensors, data-transmission schemes and data processing.

The system described here is designed to provide hoist operators and maintenance and inspection personnel with a real-time indication of the operational status of a mine-shaft hoist conveyance. Figure 2 shows the concept as configured on the top of a skip. It consists of three sensors: a Flex-Beam load cell

Earlier investigators defined safety features and operating and maintenance standards for hoists *in a controlled laboratory setting. Field tests in full-size shafts are now underway.*

(US Patent No. 5,728,953), an optical encoder and a potentiometer.

The load cell indicates wire rope

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