Leveraging IIoT to improve machine safety in the mining industry

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Special Extended Abstract

Each year, hundreds of mine workers are involved in machinery-related accidents. Many of these accidents involve inadequate or improper use of lockout/tagout (LOTO) procedures. To mitigate the occurrence of these accidents, new safety methods are needed to monitor access to hazardous areas around operating machinery, improve documentation/monitoring of maintenance that requires shutdown of the machinery, and prevent unexpected startup or movement during machine maintenance activities. The U.S. National Institute for Occupational Safety and Health (NIOSH) is currently researching the application of Internet of Things (IoT) technologies to provide intelligent machine monitoring as part of a comprehensive LOTO program. This paper introduces NIOSH's two-phase implementation of an IoT-based intelligent machine monitoring system.

Background

Of the hundreds of machinery-related accidents occurring every year in the mining industry, incidents involving stationary machinery at surface mines continue to be among the most frequent [1]. A NIOSH study found that the majority of fatal accidents involving stationary machinery at surface mines occurred at sand and gravel (38 percent) and stone (26 percent) operations. Of these accidents, entanglement in conveyor components was the most common cause of fatal accidents (48 percent) [2]. The same study found that one-third of these accidents involved improper LOTO procedures as a contributing factor. The U.S. Mine Safety and Health Administration (MSHA) acknowledged this problem, stating in a recent request for information, or RFI [3]: "Since 2007, there have been 17 fatalities related to working near or around belt conveyors, of which 76 percent were related to miners becoming entangled in belt drives, belt rollers and discharge points. Factors that contribute to entanglement hazards include inadequate or missing guards, inadequate or an insufficient number of crossovers in strategic locations, and/or inappropriate lock out/tag out procedures. Systems that can sense a miner's presence in hazardous locations; ensure that machine guards are properly secured in place; and/or ensure machines are properly locked out and tagged out during maintenance would reduce fatalities."

In response to this problem, NIOSH's Spokane Mining Research Division (SMRD) is exploring the potential application of IoT technologies to provide cost-effective intelligent machine monitoring systems for improved worker safety [4,5]. For phase I of this project, SMRD partnered with Central Pre-Mix Products, a subsidiary of Oldcastle APG, a CRH company, to develop and install a proof-of-concept wireless IoT solution to monitor machinery and conveyors during operation and maintenance. The primary goals of the installation were to provide real-time monitoring of access points and facilitate the planning and execution of LOTO procedures. Phase II, which is presently underway, considers expansion of the system in scope and functionality.

Phase I

The first phase in developing the intelligent monitoring system at Central Pre-Mix involved monitoring equipment and concrete batch temperatures, managing lockout/tagout, and tracking confined space entry. The development and field installation served as proof-of-concept for an IoT solution to machine safety while addressing specific safety concerns at the batch plant. This system is informational: it provides real-time data on intrusions, safety status and LOTO, but it is not intended to automate these functions.

Phase II

NIOSH researchers have already begun work on the second phase of this project. The first goal is to expand the system by scaling up the network. This means a greater number of nodes covering a wider field and will, naturally, increase the network complexity. The second aim is to add functionality to the system, such as predictive failure analysis and proximity detection. Throughout development, there will also be hardware and software revisions in order to provide the best-fit solution for each site. The third, and possibly most important, task in phase II will be to evaluate the impact of the system on a worker's situational awareness (SA). This will include refining the user interface, filtering data in order to provide the most relevant information, and finally testing and evaluation to make certain our system is improving SA.

Conclusion

Initial testing of the IoT monitoring system, in collaboration with Central Pre-Mix, has successfully demonstrated a method for electronically tracking and confirming lockout/tagout. Additionally, the system has proven capable of reliably archiving lockout/tagout and confined space entry data. Early work has also provided equipment and batch temperature readings, both of which are available in real time to workers. The mesh network employed has proven viable in an extreme environment, and results indicate a cloud-based solution will meet the system's needs. Phase I provides a clear example of the promise in bringing IoT to the mining industry, reliably and at a low cost.

Early work on phase II of the project is promising. NIOSH researchers are currently expanding on the existing intelligent monitoring system in terms of scope and functionality. The final, comprehensive system is expected to include predictive failure analysis using historic data archived in phase I, as well as additional sensors to provide monitoring things such as proximity detection to hazards, or localized environmental conditions. Further, the final system will be scalable to larger installations, with hundreds of sensors in operation. This is expected to save time, improve workers' situational awareness and reduce accidents in the workplace. Development will strive to maintain low cost, accessibility, and ease of use, in order to ensure wide adoption. ■

Disclaimer

The findings and conclusions in this paper 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. Mention of any company or product does not constitute endorsement of NIOSH. On behalf of all authors, the corresponding author states that there is no conflict of interest.

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Overview of current U.S. longwall gateroad support practices: An update

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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

In 2015, 40 longwall mines provided nearly 60 percent of U.S. underground coal production. During this time, about 80 percent of ground-fall-related fatalities occurred in areas where the mine roof was supported. In an attempt to better understand the status quo of current longwall support practices in the United States, during a period between 2010 and 2017, researchers from the U.S. National Institute for Occupational Safety and Health (NIOSH) visited a sample of 25 longwall mines representing nearly 50 percent of the currently active longwall mines operating in all of the major U.S. longwall producing regions. The data presented here indicate that the types and amount of roof support being installed in modern U.S. longwall mines have reduced ground-fall accident and injury rates to levels never seen before. However, the complete elimination of unintended roof falls in U.S. longwall mines has remained elusive. The data in this paper can be used by mine operators and engineers to determine where their chosen type and density of roof support occur on the spectrum of observations contained in this database. Additionally, this data can be used to enhance, supplement and support additional research on longwall gateroad support systems.

Background

Maintaining ground stability in gateroad entries is essen-