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The Need for Mechanization of Cable Handling Behind Continuous Miners

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Abstract

The productivity of underground mines has increased dramatically since the intro-duction of continuous miners. A variety of new hazards have developed as a result. In the spring of 2004, Mine Health and Safety Administration (MSHA) held a workshop to brainstorm ideas to decrease the number of injuries associated with continuous miners. One of the main areas of discussion at the workshop was "trailing cable-handling injuries." The method of handling the power cables over the years has changed very little while the technology and uses of continuous miners has advanced dramatically.

This paper will discuss the main ideas brainstormed at the MSHA continuous miner (CM) trailing cable handling workshop and the history and root causes of cable-handling injuries, as well as proposed ideas developed at the National Institute for Occupational Safety and Health (NIOSH) to alleviate some of the cable handling issues.

Introduction

The energy needs of the United States (US) grow every day, with coal being the major source of electricity. As shown in Figure 1, on the next page, the production of coal is continuously increasing to meet the electricity demand of consumers.

Figure 1 on the next page demonstrates that underground production is still a large part of the production of coal. With the passage of the second phase of the Clean Air Act, underground mines and reserves that were not in operation or profitable because of compliance issues will now begin to come on-line. In 2003, there were a total of 352,785,000 short tons of coal mined underground in the US (EIA, 2005). Of that total, 160,763,000 short tons were mined by continuous miners (EIA, 2005). It is likely that the tonnage of coal mined under-ground will continue to increase. Therefore, there is a need to focus on injury prevention in underground coal mines. This paper discusses the main ideas brainstormed at the Mine Health and Safety Administration (MSHA) Continuous Miner Trailing Cable-Handling Workshop and the root causes of cable handling injuries. Ideas developed at National Institute for Occupational Safety and Health (NIOSH) to alleviate some of the cable handling issues will also be discussed.

MSHA Workshop and Summary Statistics

On April 29th, 2004, MSHA held a workshop to address injuries associated with continuous miners. Attendees included laborers, equipment manufacturers, MSHA and NIOSH personnel, and mine operators. In the literature for the meeting MSHA published the following statistics compiled from the 7000-1 forms. For the time period from January 1983 – April 2004 a total of 11,367 accidents involving continuous mining machines were reported. The top three tasks being performed when the accidents took place were (MSHA, 2004):

1) Operating CM – 3,756 accidents,
2) Maintenance – 1,255 accidents, and
3) Moving Cables – 847 accidents.

The statistics above show that moving power cables is and will continue to be a problem in underground coal mines. It is imperative a solution be found.

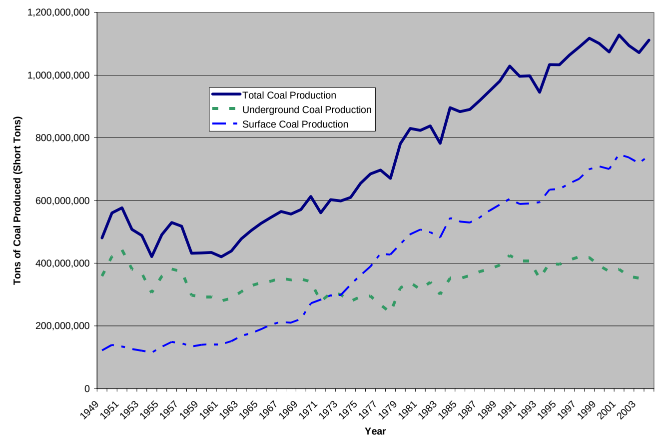

Figure 1. History of coal production in the United States.

At the workshop, a brainstorming session was held to identify ideas that could be implemented to solve some of the CM accidents. The main ideas identified to reduce CM accidents were: wireless communication – this would allow the CM operator to know where other workers are located, remote control shutdown units for employees – would prevent accidents where workers got into close proximity to the CM, and a cable real mechanism. The cable real mechanism would eliminate manual handling of the cable and keep CM helpers out of the proximity of the CM. Currently, operators and helpers have to get into hazardous areas of the CM to move the power cables.

Taxonomic Analysis and Results

After the workshop, the authors decided to look at the statistics and determine if a root cause of cable handling injuries could be identified. It was decided to use a method that has previously been used to classify crane fatalities (Shephard et. al, 2000) and root causes of groundfalls (Biswas and Zipf, 2000). This method is a taxonomic analysis. Basically, "taxonomy can be described as observation, description, and classification of data into hierarchical groups according to common patterns and individual differences" (Shephard et al., 2000). The key to this type of root cause analysis is having enough quality data to allow the root causes to be identified. This paper used information derived from the 7000-1 forms that MSHA collects and places into a database.

Since the MSHA database is so large the authors decided to place constraints on the data that would allow a more manageable database. After reviewing the background literature from the MSHA workshop and comparing it to the data that the authors collected, it became apparent that CM cable-handling injuries not only occur at the CM but also away from the CM. With that in mind, the following criteria were developed to collect the data set (MSHA, 2003):

- Mine Status – Active (coal)
- Mine Worker Activity at Time of Injury/Illness – Move power cables

- Subunit Operations within Mines – Underground operations
- Canvas or Class – Anthracite Coal and Bituminous Coal
- Years - 1999-2003

Once the data was entered into a spreadsheet a key word search of the narratives using the words "miner" or "continuous" miners was performed to eliminate the moving power cable accidents that were not related to the continuous miner. This process gave the authors a dataset of 634 accidents from the period of 1999-2003. It is possible that a very small number of records could have been eliminated with this search but the authors felt that the statistical significance of those records will not affect the results of the study. After analyzing the narratives from the data set, a taxonomic classification system containing seven layers (taxons) ranging from the broadest classifications to the most specific classifications was created.

The first layer identified the incident as a continuous miner accident. The second layer indicates where the accident occurred. For this study there were only two locations: the face and all other locations. The third layer is the accident/injury/illness layer. This layer describes accident classifications (electrical, materials handling, hand tools, etc.) The fourth layer is the accident type (struck against stationery object, etc.). The fifth layer is the nature of injury/illness (burn, hernia, cut, etc.). The sixth layer is body part affected in accident (arm, back, shoulder, etc.). Finally, the last layer is the action discerned from the narratives. The authors of the paper read every narrative and tried to determine the root cause of each accident from the narrative written for it. Ten categories of actions emerged to classify the narrative. These actions include: 1) lifting, 2) pulling, 3) twisting, 4) hanging or lowering, 5) throwing, 6) wielding, 7) roof fall or rock fall, 8) tripping, and 9) other. Figure 2 displays a very small section of the overall scheme.

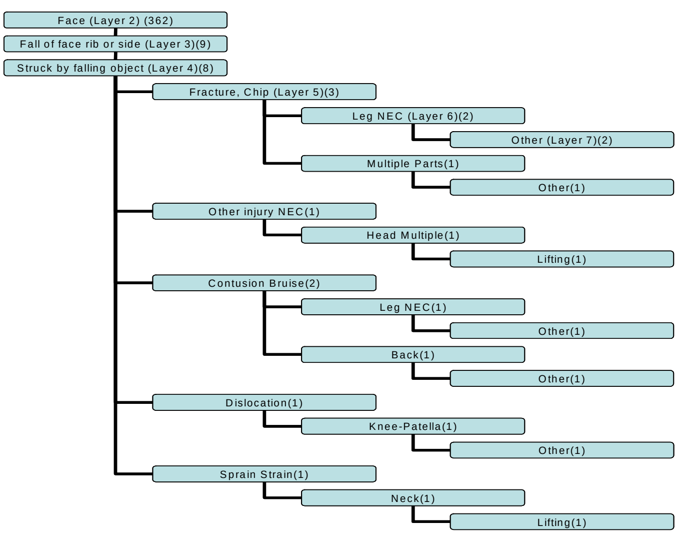

Figure 2. Small portion of the taxiometric scheme.

In looking at the figure one can see that 362 injuries occurred at the face (layer 2). Nine of these injuries occurred as a result of the fall of face, rib, or side at the face (layer 3). The rest of the figure further breaks down accidents into their respective classifications or layers. When this classification was completed a more holistic picture started to form concerning where and how cable handling accidents happen.

Proposed Ideas for Addressing the Problem

After completing all grouping and sorting of the data set, several things started to become apparent.

- Only 57% of the injuries were occurring in the face.
- Handling materials was the accident/injury/illness classification that most employees got hurt in regardless of the location (83% of all accidents).
- Over-exertion in lifting objects was the most common injury (45% face and 47% all other locations).
- Workers were most likely to have a sprain and strain (88% face and 91% all other locations).
- The most injured body part was the back (74% face and 79% all other locations).

An initial glance at the results from the sorting taxonomy suggests that there is no difference between the injuries sustained at the face and at all other locations. There is roughly a 50% chance of getting hurt either at the face or another location. Workers will most likely be injured handling materials or lifting an object. When injuries occur lifting an object, they will most likely be sprains or strains in the back. However, when looking at the actions being performed during accidents, the location makes a large difference. At the face, the majority of workers injured were pulling the cable, while in other locations the workers were hanging or lowering the cable. This difference is key. Table 1 shows the actions that workers were doing when the accidents took place by location.

Table 1. The top four actions that employees were doing when the accident took place.

Actions	All Other Locations	Face
Hanging	83	71
Lifting	33	57
Pulling	69	123
Throwing	10	8

Figures 3 and 4 serve as an example of what the worker faces when dealing with CM cables. These figures show workers moving CM cables in the face and in other parts of the section. Figure 3 is a picture of typical face conditions with mud and tight working quarters. As shown in the Table 1, most of the injuries that take place are from pulling the cable around in these conditions. Figure 4 shows two workers completing a dual lift to hang the cable back in the section. This is the proper method to hang cable, but sometimes there are not enough workers to perform the task properly.

Figure 3. Typical mining conditions at the face in a coal mine.

Figure 4. Two workers completing a dual lift when hanging cable.

After identifying the actions the workers were doing when they were injured, the authors realized that there is no silver bullet to solve the problem of cable handling injuries. Instead, it seems that and engineering solution of a total cable management system is needed. This system would manage the cable from the power source all the way to the CM. Ideally, the cable would never touch the ground. The US Bureau of Mines (USBM) commissioned a study on the creation of a continuous miner cable reel system in 1972. That report contained a list of contributing factors to the danger and cable abuse that is common in underground coal mines. The factors were:

- "The continuous miner's helper has to spend much of his time just to the rear of the mining machine so that he could prevent the mining machine backing over the cable and water line. This places the worker in an area of high mining activity exposing him to injury from the miner, shuttle car, rib bursts, and roof falls.
- The usual mine cable weighs 4 lbs/ft. This weight places a strain on personnel that handle it, which can result in back injuries, etc. As a result, mining personnel will sometimes abuse the cable by pulling it around ribs by machine and they inadvertently run over it with the miner and other machines because they are reluctant to lift it aside or hang it on roof bolts.
- Handling the cable requires personnel to grasp it firmly and in wet mines this subjects the miners to some electrical hazard.
- In less than maximum height coal the miner's helper had to remain in a crouched position, which is fatiguing.
- The hard physical labor required to handle cable causes personnel to be less attentive to safety by making them less observant of hazardous situations(USBM, 1972)."

Recently, the researchers at NIOSH's Pittsburg research center have been looking at the effects of lifting and moving cable on the back. Sean Gallagher et. al. completed a study on the "Effects of posture on dynamic back loading during a cable lifting task" (Gallagher et. al. 2002). The study had several findings and recommendations. The several of the main findings were:

- "Both posture and cable load significantly affect trunk muscle recruitment, which, in turn, influences the forces and movement imposed on the lumber spine.
- The magnitudes of the forces and moments associated with lifting the cable in this experiment were all quite high, and this may help to explain the high incidence of lost-time back injuries in the coal mining industry associated with workers who perform this task.
- The mean compression for all experimental conditions exceeded recommended values testifies to the high level of exertion required when handling such large diameter electrical cable" (Gallagher et. al. 2002).

With this knowledge from the back loading study the following recommendation was made by the back studies authors, "Efforts should be made to provide workers with mechanical assistance when performing this demanding task" (Gallagher et. al. 2002)

Figure 5 on the next page shows an artist concept from the USBM report of a cable management system. In this system the cable never touches the ground. The two main reasons for the selection of a system like this are:

1. Trailing cable reels or take-up devices mounted on continuous miners are too bulky or have insufficient capacity to be practical.
2. Pulling the trailing cable through a system of overhead pulleys from a storage reel at the load center is impractical because mining machinery has wide ranging and frequent movements.

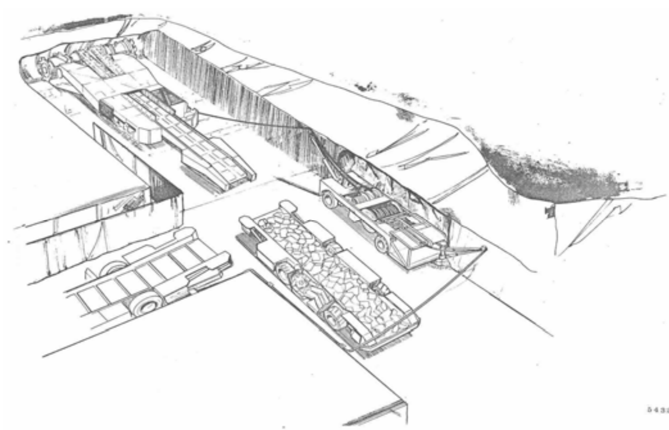

Figure 5. Artist concept of a cable management system.

Recommendations and Conclusions

Accidents from handling continuous miner trailing cables have been an ongoing problem since the creation of continuous miners. This problem is one that will be ongoing, in the authors' opinion, for the following reasons could become worse in the near future.

1) With the anticipated increase in coal production the number of CM's in use will increase.
2) To meet the anticipated increase in coal production new mines will have to be developed. Most of the development work is done with CM's.
3) Finally, the influx of new miners to these mines will bring inexperience to the industry not seen since the early 1970's.

As shown by the data in this paper, the problem is not only near the continuous miner but also from the power center to the continuous miner. While the USBM in the 60's and 70's realized it was a problem, the issue is complex and has not been resolved. With current technology, engineering, and innovation, it is possible that industry, labor, and government could come together to solve an issue that has plagued underground coal mines since the invention of the continuous miner. The authors recommend that a cooperative agreement between industry, manufacturers, labor, and government be created to develop a cable management system that allows the mechanization of cable handling for CM trailing cables.

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