Conference Paper

Causes of Fatal Accidents Involving Coal Hauling Trucks at a Coal Mining Company in Indonesia

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Abstract

Road hauling accidents involving hauling trucks are the highest contributor to coal mine accidents in Indonesia. More than 20 percent of accidents related to coal mining occur on hauling roads. PT X is an open-pit coal mining company that transports coal for processing using hauling trucks. At this company, coal hauling truck accidents also result in the highest number of fatal incidents. During the 2010–2015 period, 11 fatal accidents were reported, and hauling trucks were involved in 45 percent of the accidents. These fatal accidents resulted in the operators' deaths and also caused financial losses because of the subsequent needs to repair equipment and to disrupt production processes. The purpose of the present study was to identify the causes of fatal accidents involving coal hauling trucks at PT X during the 2010–2015 period. The research process consisted of five steps, including a (1) literature review, (2) a review of accident investigation reports, (3) field observations, (4) focus group discussions (FGDs) and (5) interviews with top management representatives. The results of the data analysis showed that two main factors cause fatal accidents involving coal hauling trucks: operator fatigue and the use of mobile phones while driving. Operator fatigue contributed to 60 percent of accidents, while the use of mobile phones while driving contributed to 40 percent of accidents. The results of the FGDs indicated that fatigue among the operators of hauling trucks was caused by poor shift management. Meanwhile, the use of mobile phones while driving was related to the monotony of work, the lack of an open radio channel and personal reasons. To reduce fatal accidents involving coal hauling trucks, we suggest to the management of PT X that the work shifts of operators be appropriately managed. A rotating shifts schedule should be implemented, and rest periods should be encouraged during shifts to avoid operator fatigue and decreased operator alertness during day shifts. Finally, we suggest the implementation of further regulations to prohibit the use of mobile phones while driving.

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Received: 15 May 2018
Accepted: 3 June 2018
Published: 19 June 2018

Publishing services provided by Knowledge E

Selection and Peer-review under the responsibility of the ICOHS 2017 Conference Committee.

Keywords: coal hauling trucks, fatality, fatigue, accident cause

1. Introduction

Fatal haulage accidents most often involve a loss of control or collisions caused by a variety of factors. In surface haulage, human performance is a critical issue, as vehicles place high demands on their human operators [1–5]. Many factors contribute to haul truck-related fatal and non-fatal injuries, including lack of visibility, road conditions, operator behaviour, operational conditions and weather conditions [4]. From the operator's perspective, the factors that affect driving tasks can be grouped into three major categories: impaired visibility, fatigue and human error [3].

Furthermore, fatal accidents involving coal hauling trucks result in operator deaths and also cause financial losses to companies because of the subsequent needs to repair equipment or to disrupt production processes. Hexagon Mining [6], a typical surface mining operation, created the SAFE Collision Avoidance and Traffic Awareness System. One of the functions of this programme is to estimate the potential costs of collisions. Although it has some limitations, this programme provides useful guidelines on the magnitude of costs suffered by individuals, industry and society following such accidents.

In particular, road hauling accidents related to coal mining are the highest contributor to the number of coal mine accidents in Indonesia. During the 2010–2014 period, 25 percent of coal mining accidents occurred on hauling roads [7]. PT X is an open-pit coal mining company that transports coal along 80 km of hauling roads from the mining site to the loading terminal at the Barito River. The coal hauling processes involves over 300 double-trailer trucks with a maximum capacity of 130 tonnes; these trucks are operated by contractors.

Coal hauling truck accidents at PT X are the largest contributor to the number of fatal accidents from 2010 to 2015; during this latter period, 5 fatal accidents (45 percent of total accidents) were related to hauling trucks. The causes of the fatal accidents during this period, as listed in the accident reports, are shown in Figure 1.

The purpose of the present study was to identify the causes of fatal accidents involving coal hauling trucks during the 2010–2015 period.

2. Methods

The research process consisted of five phases, including a (1) literature review, (2) a review of accident investigation reports, (3) field observations, (4) focus group discussions (FGDs) and (5) interviews with top management representatives.

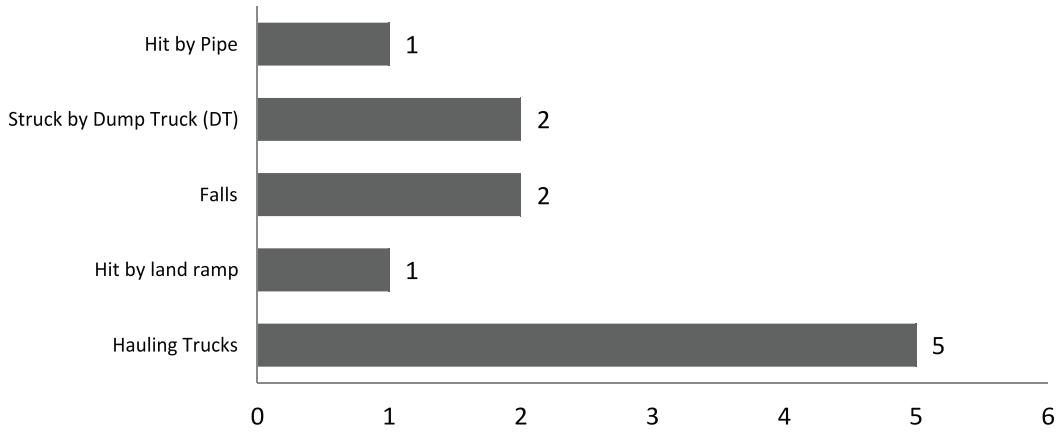

Figure 1: Causes and numbers of fatalities at PT X involving mining equipment from 2010 to 2015.

During the first phase, a review was performed of studies published in the scientific literature on hauling truck accidents associated with open-pit mines. During the second phase, a review of data on truck-related fatality accidents for the 2010–2015 period was carried out based on the investigation reports that are available on the internal website of PT X. A typical report is approximately five pages long and contains the date of the accident, the location of the accident, the age and work experience of the victim, a description of the accident, a discussion of the accident, a root cause analysis, conclusions, corrective and preventive actions and the names of the investigative team.

During the third phase, observations in addition to informal and semi-structured interviews were carried out in October 2016 to analyse and understand the work processes of the haul truck operators at PT X. Specifically, during the observations, dispatch engineers, supervisors and haul truck operators were interviewed. Two haul truck operators were also directly observed. One haul truck operator was observed during the day, and the other haul truck operator was observed during a night shift for the 120–150-minute trip from the pit to the port.

During the fourth phase, six FGDs were conducted. These discussions were carried out with a group of 6–10 people and were led by a moderator. The moderator was in charge of leading an open and spontaneous discussion to elicit different ideas and opinions from the participants. The discussions lasted 45–90 minutes, and each group convened twice in one day: once in the morning from 9:00 to 10:00 and once again in the afternoon from 14:00 to 15:30. The discussed topics included the perceptions of haul truck operators with respect to their health, safety and work environment as well as their past experiences and expectations of the safety control measures that could

be implemented in the workplace. The FGDs were held from 6 to 8 September 2016 at the offices of PT X.

The participants in the FGDs consisted of operators and supervisors from PT X and its partners. A screening method was devised for each focus group to ensure that participants were qualified to participate in the study. The age of participants (≥ 30 years or < 30 years) was recorded in addition to whether participants had worked for other mining companies (or if PT X was the first company where they had worked). Only those who complied with one of the following criteria were included in the FGDs:

1. Experience with haul trucks accident
2. Ever received sanctions
3. Tend to behave 'stubborn' based on the result of communication with the supervisor concerned
4. Behaved neutrally
5. Had been an operator in the past (applied to both operators and supervisors)

During the final phase, interviews were conducted with top management officials to obtain advice and opinions from a management perspective on fatal accidents related to haul trucks and on preventative measures that can be implemented in the workplace. The interviews lasted for 30–45 minutes and were conducted in November 2016 at the management offices.

3. Results

3.1. Literature review

Several studies on fatal accidents involving coal haul truck operators were analysed. Randolph [1] notes that, during surface haulage, human performance is a critical issue as vehicles place large demands on their human operators. These demands are related to the following factors:

1. Roadways and work areas change frequently
2. The sheer mass of trucks sometimes requires control inputs (e.g., braking) far in advance of a desired action
3. In large operations, the drive into and out of a pit can be long and tedious

4. Rough roads and loading impacts can subject the driver to dangerous shocks and vibrations
5. Visibility is sharply curtailed by the bulk of the vehicle

Meanwhile, Orchansky [3] stated that fatigue is the most critical contributing factor towards vehicle accidents in the mining industry and is the direct cause of hundreds of serious injuries and fatalities every year. Fatigue affects the alertness and performance of drivers by decreasing their reaction time and impairing their judgment capabilities, thereby leading to a higher risk of motor and cognitive errors.

Hanowski, as cited in Orchansky [3], provided a preliminary list of potential fatigue-related factors cited by long-haul- and short-haul drivers. The most frequently mentioned factors are listed as follows in order of most to least mentioned:

1. Lack of sleep
2. Hard/physical workday
3. Heat and/or no air conditioning in cab
4. Wait times to unload
5. Irregular meal times
6. Long hours
7. Irregular work shift
8. Sickness
9. Frustration
10. Lack of balance between work and personal life

In the present study, we examined two factors: long work hours and irregular work shifts. These factors were determined as the main reasons for operator fatigue during the field portion of the study.

3.2. Review of accident investigation reports

Figure 3 shows the distribution of haul truck-related fatalities at PT X from 2010 to 2015. The highest number of haul truck-related fatalities occurred in 2010.

Detailed information on these fatal accidents is described in Table 1. The accident information consists of the date of the accident, the location of the accident, the type

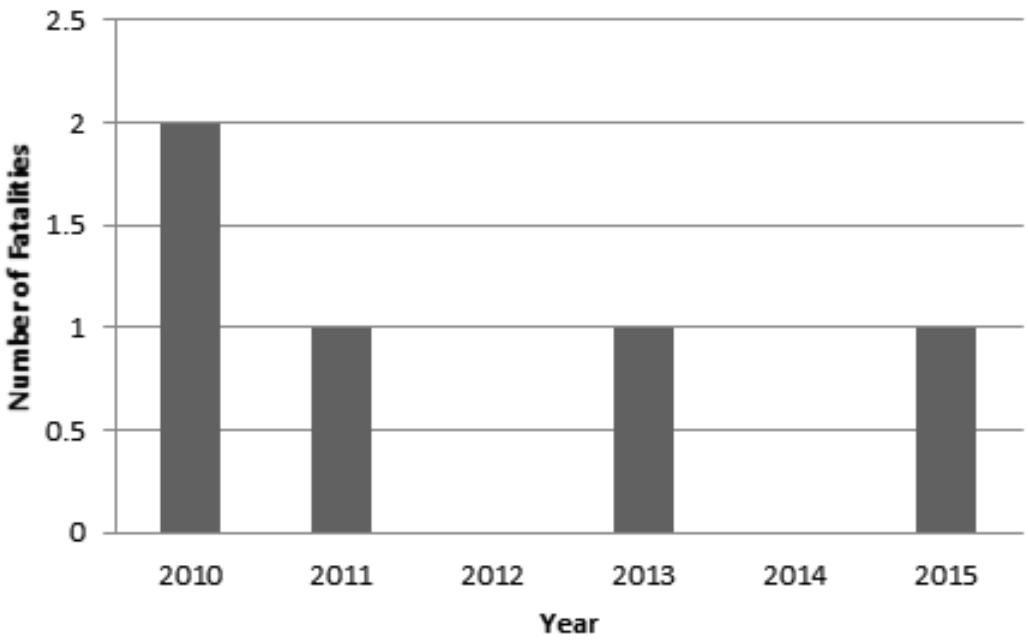

Figure 2: Distribution of haul truck-related fatalities at PT X from 2010 to 2015.

of the accident, a short narration of events and the immediate and root causes of the accident. The immediate cause of fatal haul truck accidents is operator fatigue, which contributed to 60 percent of accidents; the remaining accidents were related to the use of mobile phones while driving.

Table 1: Detailed accident information from 2010 to 2015.

No	Date	Location	Type	Narration	Immediate Causes	Root Causes
1	13 Jan 2010	Hauling road	Collision	The unit collided with another unit coming from the opposite direction	Use of a mobile phone while driving	Lack of safety knowledge
2	14 Mar 2010	Hauling road	Collision	The unit crashed into another unit as it was turning	Use of a mobile phone while driving	Lack of safety knowledge
3	6 Nov 2011	Hauling road	Rollover	The unit crashed into a bund wall and rolled over	Driving under fatigue	Inadequate vehicle control
4	4 Sep 2013	Hauling road	Collision	The unit was being operated off of the road and crashed into trees	Driving under fatigue	Operator pushed himself to work under unfit conditions
5	12 Jun 2015	Hauling access road to mine	Collision	The unit crashed with another parked unit	Driving under fatigue	Operator was dishonest with respect to his fitness to work

3.3. Field observations

Haulage from the open-pit mine of PT X is highly cyclical in nature. A haul truck is assigned to transport coal from the pit to the unloading site/port. A haul truck will transport coal from the pit to the port, which is located at a distance of ± 80 km from the pit. This trip takes approximately 90 minutes under normal conditions. The hauling road is also used by various other vehicles, including local residents' cars, minibuses, employee buses, fuel trucks and even motorcycles.

Figure 3: Cyclical haulage operations at the open-pit mine of PT X.

The hauling roads used by PT X experience high traffic and represent a tight network of roads with various intersections. Drivers regularly meet other traffic and must stop or reduce speed at intersections. Consequently, the hauls can be very long, so drivers experience a high task load and must have a high level of concentration. Similar to the results of Stahl [8], these conditions are challenging both for haul trucks and other vehicles and may increase the risk of accidents, especially at night under poor lighting conditions. In addition, during the observations along the hauling road, several rest areas were noted, although few toilet facilities were found. Also, the road conditions along 0–30 km were poor.

A feasibility study of mine road safety was conducted by PT X in 2013. This study proposed some improvements such as closing community access roads and replacing these with flyovers, constructing parallel roads for citizen motorists, constructing fences along the hauling roads and inspecting road constructions. However, while in the cabin, the operator's primary task is to navigate the coal truck. The operator must be aware of the current state of the truck and the environment and mainly relies on visual cues, despite poor visibility and lighting conditions. In addition, the operator must be aware of vibrations from the coal truck itself, noise from the engine and the state of the roads, especially along the road sections in poor conditions. In addition, the operator performs other tasks such as communicating with other parties to exchange

information and/or to plan or coordinate specific actions with multiple hauling vehicles via radio.

During the loading and unloading process, operators merely sit in the idling trucks and communicate over the radio. However, the initial manoeuvring to correctly position the truck, especially a double trailer, next to the shovel is a particularly challenging task. The operators solely depend on two rear-view mirrors to perceive the position of the truck relative to the shovel [8]. The unloading phase also requires a high level of concentration but is less complicated than manoeuvring next to the shovel as a camera is used to guide the dumping of the contents.

3.4. Focus group discussions

During the FGDs, the discussions revolved around perceptions of health, safety, the working environment and fatal accidents as well as issues related to operator fatigue. Following are the main observations and points mentioned by the participants in the FGDs.

1. The shifts and rotation of shifts differ per operator and supervisor and per contractor. For example, under contractor A, operators work 3 shifts (shift 1 for 7 days, shift 2 for 7 days, and shift 3 for 6 days), while supervisors work 2 shifts of 13 working days and have 1 day off. Under contractor B, operators work 2 shifts of 6 working days and have 1 day off, while supervisors work 2 shifts of 6 working days and have 1 day off.

2. Permission to take time off of work because of fatigue affects the annual performance appraisal of operators, which is applied by one of the contractors. Also, some operators may be unfit to work, yet their need to work and make money may affect their honesty when filling out the 'fit to work' form.

3. Both contractors have a fatigue management programme. These programmes are quite effective but need to be improved. For example, a fatigue inspection could be performed at certain hours, and operators could be provided with coffee.

4. New operators are afraid to report their fatigue to supervisors.

5. Unsafe conditions, such as low visibility, may be caused by dusty roads, for example. Some operators are afraid to stop or slow down because they do not want to be reprimanded by supervisors.

6. Some operators have had near miss accidents that have gone unreported to supervisors.

7. One of the main fears of operators is being terminated in the event of an accident/near accident.

8. Supervisors wish to be involved in accident investigations because they understand the actual conditions in the field.

9. During some accident investigations, the investigators purportedly only examine the superficial causes without exploring the root causes in greater depth.

3.5. Top management interviews

From the perspective of management, PT X has many programmes related to health and safety in mining. One of these programmes is oriented towards fatigue management. However, these programmes do not seem to be efficiently organised or properly executed to the benefit of workers. Many workers are unaware of the direct benefits of the programmes or whether the programmes are achieving their objectives.

Even so, management is not planning to develop new programmes but rather improve the existing programmes. Notably, managers expressed that PT X needs a new method to ensure that operators or drivers are dutiful and follow regulations and that supervisors are also vigilant of potential problems.

4. Discussion

Accidents related to fatigue (60 percent of all accidents) accounted for the largest share of accidents at PT X. Some of these accidents resulted in fatalities. For example, in 2011, a haul truck operator crashed into a bund wall and his truck rolled over. The results of the FGDs showed that fatigue is felt among many operators with short shifts compared to those with longer shifts (2 shifts). Fairly rapid shift changes (rotating shifts) also contribute to fatigue. Also, operators often dedicate significant time to their daily commute because of the remote location of the mine. Operators reported commuting between one to two hours every day. Long commutes can even exhaust workers before they arrive at the workplace. Also, working the night shift represents a complex physical task and is a unique situation that should receive special attention, especially on hauling roads with poor lighting conditions.

In the present context, fatigue is the decline in mental and/or physical performance that results from prolonged exertion, lack of quality sleep or disruption of the internal body clock [9]. According to several definitions, the symptoms of fatigue may differ, yet fatigue generally results in reduced work capacity and body resistance. Fatigue involves physiological as well as psychological aspects and is largely subjective. However, fatigue clearly leads to decreased physical performance, decreased motivation and decreased work productivity.

To face these issues regarding fatigue, PT X previously issued a memorandum to prohibit operators from working while fatigued and allowed operators to stop working and return home if fatigued. However, some operators are dishonest when filling out the 'fit to work' form because they do not want to lose money. Moreover, rotation bonuses are lost if production targets are not achieved. For these reasons, the contractor company allows operators to work even if they sometimes feel fatigued.

According to the results of a study on the safety culture of PT X contractors performed by a consultant, several causes of inadequate rest among operators were identified: family financial problems, watching football games on TV at night and personal problems with family. Also, operators often do not report the actual number of hours of rest/sleep during fatigue checks because they want to keep working and earning income. In addition, the consultant found that the seniority mindset, or desire to achieve seniority, influenced workers' safety behaviours and openness about readiness to work.

With respect to the work system at Indonesian mines, Republic of Indonesia Law No. 13 on manpower was adopted in 2003 to place a limit on the number of hours worked per week at 40 hours. A company-specific work system is established by each mining company and tailored based on the desired targets and production capacity. At the mine we observed, two contractor companies operate trucks for hauling coal. Contractor A assigns operators to work 3 shifts of 8-hour duration (with a 30-minute break) and uses a 7-7-6 rotating shifts system. Meanwhile, contractor B assigns operators to work 2 shifts of 12-hour duration (with a 30-minute break) during 6 working days followed by 1 day off.

According to the National Traffic Commission (NTC) [10], the maximum working hours of heavy vehicle drivers, or the maximum allowed driving time, should be 12 hours within a 24-hour period. A minimum rest of 7 uninterrupted hours should also be taken within the same period.

Rotating all shifts every 2–3 days is recommended, as the internal body clock does not adapt. Also, sleep loss can be quickly recovered to reduce the risk of fatigue and ill

health. If quick rotations are not possible, then slowly rotating shifts over at least a 3-week period is the next best option. In addition, night shifts disrupt the internal body clock, and night workers also suffer from sleep loss, poor sleep quality and fatigue. Only a limited number of workers can successfully adapt to night work. Alternatives to night work should be found for those workers who cannot adapt. When possible, permanent night shifts should be avoided. Some differences exist in the effects of 8-hour and 12-hour shifts on workers, yet no obvious advantages are present in either system. However, the nature of the work also should be considered. Eight-hour shifts are preferable when work is monotonous, isolated or critical or when work tasks demand high concentration or vigilance. Also, exposure to work-related physical or chemical hazards should be considered [9].

A final important result from the FGDs was related to the use of mobile phones by operators while driving. Operators generally use mobile phones to eliminate the boredom caused by monotonous work. As mentioned, drivers must drive 80 km back and forth each day and over the same haul road. Also, drivers must use mobile phones in some instances to quickly communicate with supervisors when the radio channel is too busy, as all vehicles passing along the hauling road must use the same radio channel frequency. In addition, operators sometimes call family or their partners. Some control programmes have been implemented to prohibit the use of mobile phones while driving, such as road patrols, the installation of traffic safety signs along the hauling road, defensive driving training for all haul truck operators and the implementation of 'fit to work' standards.

5. Conclusion

Operator fatigue and the use of the mobile phones while driving are the main factors that cause fatalities during accidents related to coal hauling trucks at PT X. Shift work or rotating shifts at night-time can lead to the disruption of the internal body clock, the disruption of sleep and fatigue. Also, the monotony of work, the use of a sole radio channel and several personal reasons lead operators to use mobile phones while driving.

Acknowledgements

The authors thank the management of PT X for their valuable comments and inputs.

Funding

This work was supported by an internal grant of the Health, Safety and Environment (HSE) Division PT X.

References

[1] Randolph, R. F. and Boldt, C. M. K. (1996). Safety Analysis of Surface Haulage Accidents. US Department of Energy, Pittsburgh and Spokane Research Centers.

[2] Drury, C. G., Porter, W. L., and Dempsey, P. G. (2012). Patterns in mining haul truck accidents. Proceedings of the Human Factors and Ergonomics Society Annual Meeting, vol. 56, no. 1, pp. 2011–2015.

[3] Orchansky, D., Worrall, S., Maclean, A., et al. (2010). Designing a user interface for improving the awareness of mining vehicle operators. IEEE Conference on Intelligent Transportation Systems, Proceedings, ITSC, pp. 1435–1441.

[4] Groves, W. A., Kecojevic, V. J., and Komljenovic, D. (2007). Analysis of fatalities and injuries involving mining equipment. Journal of Safety Research, vol. 38, no. 4, pp. 461–470.

[5] Schutte, P. C., Maldonado, C. C. (June 2003). Factors Affecting Driver Alertness During the Operation of Haul Trucks in the South African Mining Industry (Project No. SIM 02 05 02 (EC03-0295)). Safety in Mines Research Advisory Committee.

[6] Hexagon Mining. Hexagon mining. Hexagon Mining Newsletter.

[7] KESDM. Kecelakaan tambang di Indonesia, 2010–2014. (2014).

[8] Stahl, P., Donmez, B., and Jamieson, G. A. (2012). Analysis of the interaction between human operator and automated dispatch in haul truck scheduling. Proceedings of the Human Factors and Ergonomics Society Annual Meeting, vol. 56, no. 1, pp. 2291–2295.

[9] Health Safety Executive. (2006). Managing Shiftwork: Health and Safety Guidance (p. 1–45). HSE books.

[10] NTC Australia. (July 2008). Standard Hours Explained (Heavy Vehicle Driver Fatigue Reform, Information Bulletin).