tion rate of pressurized alkaline leaching process is mainly controlled by the chemical reaction, and the reaction rate can be adjusted by changing temperature or pressure. The activation energy of the reaction is 19.53 kJ/mol. The low value indicates that the energy consumption of the pressurized alkaline solution method is low, which is beneficial to its industrial application.

Conclusion

Spent alumina catalyst was treated by pressure alkali solution, and the optimal leaching conditions were obtained as alkali concentration of 240 g/L, temperature of 200 °C, pressure of 1.20 MPa, holding time of one hour and liquid-solid ratio of 5:1. The experimental results show that the leaching rate of Al_2O_3 was 99.69 percent, and the enrichment rate of platinum was increased by 120.82 times.

When the temperature is 170~200 °C, the leaching process of the catalyst is controlled by the chemical reaction, and the activation energy of the catalyst is 19.53 kJ/mol. Pressurized alkali solution can not only efficiently leach alumina from the spent catalyst and enrich platinum, but also can reduce reaction time and increase reaction rate. ■

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The necessity for improved hand and finger protection in mining

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Special Extended Abstract

Injuries associated with hands and fingers are highly prevalent in the mining industry, and identifying factors associated with these injuries is critical for developing prevention efforts. This study identifies nonfatal injury incidence rates, nature of injury, work activities, glove usage, and sources of hand and finger injuries in the U.S. mining industry, as reported to the Mine Safety and Health Administration (MSHA) from 2011 to 2017. Hand and finger injuries occur at a rate of 6.53 per 1,000 full-time employees, which is nearly double the rate of the next highest affected body part, the back. Most of the hand and finger injuries were classified as cuts/lacerations/punctures (53 percent) followed by bone fractures/chips (26 percent). Materials handling and maintenance/repair were common activities at the time of the incident with miscellaneous metals — such as pipe, wire and guarding — and hand tools as the primary sources of hand and finger injury. Although the information on glove use was limited, leather gloves were most often worn when an injury occurred. When gloves were identified in the injury narrative, gloves contributed to 20 percent of the injuries, indicating their potential to protect the hands but also potentially putting the hands at risk. Further research is necessary to determine performance requirements for gloves used in mining operations, specifically those offering cut and puncture resistance.

Table 1 — Hand and finger injury counts and rates by mining sector and operating location, 2011-2017.

Mining sector	Underground operations	Surface operations	Mill or preparation plants	Total
Coal count	3,924	1,056	400	5,380
*Rate**	*12.73*	*3.52*	*4.96*	*7.81*
Noncoal count	654	3,481	3,008	7,143
*Rate**	*7.07*	*5.10*	*6.62*	*5.81*
Metal	441	804	816	2,061
Nonmetal	133	292	523	948
Stone	80	1,475	1,669	3,224
Sand and gravel	0	910	0	910
Total count	4,578	4,537	3,408	12,523
*Rate**	*11.43*	*4.62*	*6.37*	*6.53*

*Rates are presented per 1,000 full-time equivalent mine workers. Due to the way MSHA collects contractor employment data, rates can only be calculated for coal and noncoal employment categories. Noncoal consists of the metal, nonmetal, stone, and sand and gravel mining sectors.

Background

Hands and fingers are the most injured body part annually across all industries, accounting for nearly 10 percent of lost time injuries [1]. The U.S. mining industry has been plagued by hand and finger injuries for decades, and these injuries may pose a significant burden on mining company finances and worker quality of life [2-4]. Gloves are a common means of protecting hands and fingers; however, they may reduce hand performance and even contribute to injury. This paper presents a detailed descriptive analysis of hand and finger injuries sustained by mine workers, highlights the factors associated with injuries and identifies performance metrics for improved glove design.

Methods

Public datasets provided by the MSHA were used for this analysis. Injuries were included if the injured body part included hands or fingers and excluded injuries to office workers. The final dataset included 12,523 hand and finger injuries, and injuries that involved gloves were identified via a narrative text search. This study identifies nonfatal injury incidence rates, nature of injuries, activities, tasks, and sources of hand and finger injuries in the mining industry, as well as glove use in relation to injury.

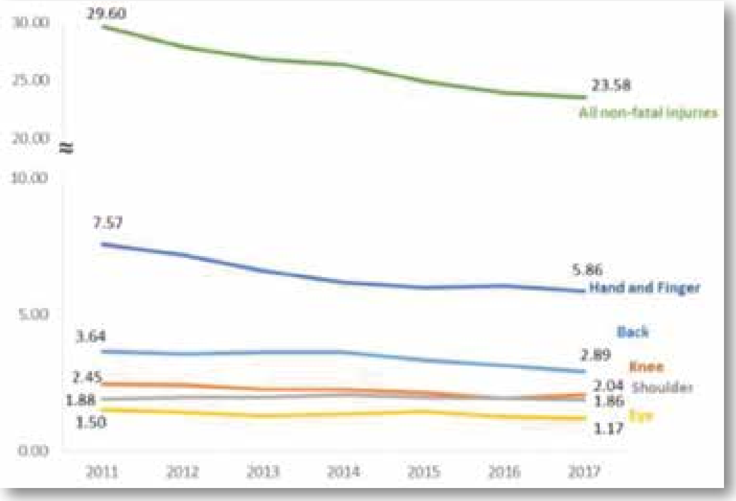

Fig. 1 Injury rates per 1,000 full-time equivalent mine workers for the most common body parts injured.

Results and discussion

From 2011 to 2017, the hands and fingers had the highest injury rate (6.53 injuries per 1,000 full-time equivalent (FTE) workers), followed by the back, knees and shoulders (Fig. 1). The average rate of hand and finger injury was nearly two times the average back injury rate. Table 1 gives the count and rates of injuries by mining sector and work location. Miners at coal mines had 1.34 times the rate of hand and finger injuries compared to noncoal mines. Injuries were most common at underground operations (37 percent) with an incidence rate of 11.43 hand and finger injuries per 1,000 FTE mine workers. Compared to surface mines, underground mines had 2.5 times the rate of hand and finger injuries.

Cuts, lacerations and puncture injuries were the most common nature of injury with 6,682 cases (53.4 percent), followed by bone fracture/chip injuries with 3,295 cases (26.3

Table 2 — Nature of hand and finger injures and resulting days lost, 2011-2017.

Nature of injury	Frequency	Percent	Cases reporting days lost	Total days lost	Mean days lost	Median days lost
Cut, laceration, puncture	6,682	53.4	5,950	54,679	9	0
Bone fracture, chip	3,295	26.3	3,107	94,897	31	14
Crushing	615	4.9	581	19,250	16	11
Contusion	559	4.5	536	8,790	16	4
Amputation	392	3.1	392	78,736	201	100
Sprain, strains	274	2.2	265	9,453	36	8
Unclassified, not determined	150	1.2	144	5,045	35	8
Burn or scald (heat)	127	1.0	121	1,943	16	5
Other injury, NEC	101	0.8	98	2,413	25	3
Multiple injuries	78	0.6	75	2,261	30	9
Dislocation	71	0.6	65	1,599	25	1
Noncontact electric arc burn	47	0.4	44	1,117	25	12
Scratches, abrasions	40	0.3	40	786	20	3
Joint, tendon, or muscle inflammation or irritation	36	0.3	29	635	22	4
Electrical burn	25	0.2	23	448	20	6
Burn, chemical	16	0.1	15	368	25	5
Dermatitis	10	0.1	7	9	1	0
Freezing, frostbite	5	0.0	5	1	–	–
Total	12,523	100.0	11,497	282,430	–	–

percent). Bone fracture/chip injuries accounted for the most total days lost from work between 2011 and 2017, accounting for 94,897 total lost days. Amputations were the fifth most common nature of injury, with 392 cases (3.1 percent) but associated with the second largest total days lost from work, with 78,736 total lost days. Amputation injuries had the highest median and mean days lost from work (Table 2).

The top five work activities — materials handling, machine maintenance and repair, nonpowered hand tool use, roof bolting and powered hand tool use — made up 75 percent of the injuries. Analysis of each work activity is provided in the full paper.

Gloves were explicitly mentioned and worn in 754 injury cases. Leather gloves were most identified (90 cases, 46.9 percent), and nearly 90 percent of these cases report cut, laceration or puncture injuries. In general, leather gloves are not considered cut resistant, unless specially coated, lined or otherwise specified by the manufacturer. Metacarpal gloves were the second most common type of glove identified, with 38 cases (19.8 percent), and nearly 42 percent of these cases were related to crushing and bone fractures. Similarly, in a few cases, cut-resistant gloves still resulted in a mine worker sustaining a cut. This can indicate that either the protection was not on the appropriate location of the hand, the protection was somehow deteriorated (such as with wear), or the incident was serious enough where the gloves could not provide the necessary level of protection needed to combat the hazard. When gloves were worn, 418 (55 percent) were identified as possible cases that could have been avoided or resulted in a less severe injury if a glove offered optimal protection.

The mention of gloves in the injury narrative was low (7.5 percent of overall sample). This could be due to the lack of specificity in the narratives but could also indicate that gloves are not used often. Even with the small sample on glove use, some inferences can be drawn to help create prevention practices. In 21 percent of the cases, the gloves contributed to the incident due to the hand being caught in, under or between an object or machine. This supports the need to ensure that loose-fitting gloves or gloves which can get caught easily are not used when a risk exists for gloves getting caught in the equipment. Wearing gloves when roof bolting had 4.87 higher odds that the glove contributed to an injury compared to injuries that occur while performing other activities.

Conclusion

From 2011 to 2017, the rate of hand and finger injuries in the U.S. mining industry was dramatically higher than any other injured body part. Manual materials handling, machine maintenance and repair, and hand tool use were the most common activities associated with these injuries. While the currently available data do not allow for analysis on the effectiveness of gloves for preventing injury, evidence exists where glove protection failed and even where glove use contributed to the injury. There is a need to further evaluate hand protection strategies in the mining industry that goes over and above personal protective equipment (PPE) or gloves and includes all levels of the hierarchy of hazard controls. Moreover, glove design should be improved to ensure gloves do not create additional hazards when in use. ■

Disclaimer

The findings and conclusions in this report 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 by NIOSH.

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Air quality impact assessment and management of mining activities around an international heritage site in India

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Special Extended Abstract

In this work, a comprehensive field study was carried out to measure the background air quality status and identify the air pollution sources from opencast mines around a heritage site in India. Air quality modeling was conducted to envisage

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