

Evaluation of Performance of Metacarpal Gloves used in the Mining Industry under Impact Loads

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Extended Abstract

Hand injuries have been and still are a significant problem for all sectors of industries. In spite of the continuous advancements in the technology and the safety procedures for production and maintenance tasks, in the mining industry, there is still a significant number of employees completing manual tasks with high-risk factors (Pollard et al., 2014). According to the Accident Injuries Data Set published by MSHA (U.S. DOL, 2018), from January of 2000 to January of 2018, nearly 20% of the total number of reported accidents corresponded to injuries to the hands of the mine workers. Specifically, there were nearly 42,000 reported accidents involving “fingers/thumb” (76%) and “hand (not wrist of fingers)” (24%). Fracture or crushing occurred in nearly 30% of the accidents, and 41% of the injuries were produced by “struck of falling, flying and rolling object.” Within this last category, activities with higher incidence included accidents with non-powered hand tools (35%), machine maintenance (18%), handling supplies or material (15%) and activities that involved operations with a roof bolter machine (9%). The roof bolting tasks that showed the highest to lowest risk index were bolting, handling of materials, setting the temporary roof support (TRS), drilling, tramping, and traversing (Sammarco, 2016). All these injuries led to thousands of days lost with the consequent burden for the injured and the resulting loss of productivity.

Because the relatively high incidence of injuries involving hands, mine workers are required to wear impact protective gloves (also known as metacarpal gloves) as personal protective equipment (PPE) to protect hands from impact injuries. Metacarpal gloves are typically bulkier than conventional gloves, and the hand function is decreased when the worker is wearing those gloves (Muralidhar and Bishu, 2000; Kinoshita, 1999; Tsao and Freivalds, 1998). Normally, when wearing metacarpal gloves, mine workers and machine operators experience decreased dexterity, less flexibility, reduced tactile sensitivity as well as functional strength, which may lead to an increase in struck by or caught in injuries (Buhman et al., 2000). User acceptance is an important consideration for selection of PPE. Like any other industry, mine workers are less likely to wear PPE if it does not fit properly, is uncomfortable, or limits their dexterity, and therefore increasing their risk for injuries (Moore and Campbell, 2017).

Many models of metacarpal gloves currently available in the market are typically comprised of cutting resistant fabrics reinforced with Thermo-Plastic Rubber (TPR). TPR is the molded material placed on top of the glove that provides impact protection. TPR reinforcements are typically placed in segments located on the top of the fingers and thumb, on top of the knuckles, or on the back of the hand, or on a combination of these three positions. Other models only include thick pads placed all over the top and bottom surfaces of the glove. This diversity of designs and constructions make it difficult for the end users to select the most suitable glove for the task at hand.

There are at least forty five glove manufacturers operating in North-America that currently supply different types of industrial gloves (Dolez et al., 2010). Not all of them are suitable for mining applications. Many of those suppliers offer gloves with features designed to protect workers against individual or a combination of several hazards including mechanical protection (which requires cut resistance, puncture resistance, and abrasion resistance); chemical protection (requiring chemical permeation resistance, chemical degradation resistance and detection of holes); heat and flame protection (requiring flame resistance, heat degradation and conductive heat resistance) and protection from cold. For each one of these requirements, there are different standards typically used to classify the performance of glove products (Stull, 2016). However, to date, there is no uniform standard test to evaluate the performance of metacarpal gloves against impact hazard and to determine objective levels of impact protection. Moreover, glove manufacturers are not legally required to test the impact protection of their gloves, and this situation may lead to untrue claims and minimal protection for the user, which may lead to higher recordable injuries.

The technical literature shows very few attempts to rationalize the evaluation of metacarpal gloves against impact loads. In one of the studies, the evaluation included the measurement of the impact force to break bones of the hand using

cadaver hands (Loshek, 2015). A limitation of this study is that the range of age of the cadaver hands was between 76 and 98 years of age with an average age of 87 years which can limit the validity of the reported results. Moreover, the same study shows significant variability in the results and only a minimal amount of detail regarding the methods implemented in the study were provided. Furthermore, only a part of results obtained in the evaluation of the metacarpal gloves is publically available. Along the same line, some manufacturers appeared to have performed impact tests to qualify their products but report little or no detail on the study procedures or conditions of testing (Ringer Gloves, 2017) which make it extremely difficult to reproduce and compare their findings independently.

The few previous studies measured the reduction in hand impact force as a measure of performance of the glove against an impact and compared the performance of different gloves against no-glove testing. The percentage of reduction of the peak impact force indicated the level of performance. It is also important to note that there is no ASTM standard for this type of test. The closest one is the ASTM D2632-15 (ASTM, 2015) which, as indicated in Section 4.2 of the standard, it is a test method intended for development and comparison of materials and may not directly relate to end-use performance. That is, the ASTM protocol is suitable for material testing but not for measuring the force reduction provided by a specific glove.

Based on all the previous considerations as well as on the shortcomings seen in the published data and results, there is a clear need of carrying out an independent research effort to quantify the level of protection offered by the different types of metacarpal gloves currently in use in mining operations. We anticipate that at the completion of the proposed research effort, it will be possible to gain a clearer picture of the performance and levels of protection that the different potential end-users can use confidently for the selection of the gloves that best adapt to their needs. This work presents an experimental setup for impact testing of metacarpal gloves as well as initial experimental evaluations carried out to assess the level of protection offered by the different types of metacarpal gloves currently in use in mining operations. The performance under different types of impacts on different regions of the hand is evaluated. Different indicators are used to evaluate the level of protection of the different regions of the hand.

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