Impact abrasion resistance quantification of protective motorcycle gloves

Patrick Phillips[a], Furquan Sharjeel[b], Kyle Hickling[a] and Christopher J. Hurren[a]

[a] Australian Future Fibres Research and Innovation Centre, Institute for Frontier Materials, Deakin University, Geelong, Australia 3216

[b] School of Engineering, Deakin University, Geelong, Australia 3216

Abstract

The hands are often the first contact point with the road surface in a motorcycle crash. Wearing well designed protective gloves has been proven to significantly reduce the occurrence and severity of injuries to the hand. The European Standard for motorcycle protective gloves requires testing of component materials separately and does not consider the impact of abrasive surfaces on seems.

This work aimed to develop a new method of testing of fully constructed gloves as worn by a rider in impact abrasion situations. It used previously published fall mechanics to understand the areas that may undergo impact abrasion. It defines the important zones for abrasion resistance and details ideal impact/measurement geometry for measurement on a Cambridge type abrasion tester. It proposes a method for the impact abrasion resistance of the palm, knuckles, wrist, outer side of the little finger and the tops of fingers. This information may be used for the quantification of fully manufactured gloves for standard certification or use in a rating system.

Introduction

30% of motorcycle crashes resulted in hand injuries to the rider (Otte & Middelhauve, 1987) and numerous studies around the world have found that in a motorcycle crash, riders who do not wear any form of hand protection are at severe risk of injury. Data analysed from 900 motorcycle crashes in the USA found that in all cases of hand injuries, 74% of them occurred in crashes where the rider was not wearing any form of hand protection (Hurt, Ouellet, & Thom, 1981). A more recent study analysing 226 patients admitted to a hospital in Turkey over the course of a year found very similar results for hand injury statistics (Erdogan et al., 2013). Of riders wearing gloves, 44.7% suffered soft tissue abrasion injuries, while 80% of riders without gloves suffered soft tissue abrasion injuries.

These studies highlight the need for riders to wear hand protection while riding, however in an Australian study of 212 motorcyclist involved in road crashes it was found that 25.7% of gloves designed for motorcycle use had suffered material failure during the crash (de Rome, Ivers, Fitzharris, Du, et al., 2011; de Rome, Ivers, Fitzharris, Haworth, et al., 2011). The current European Standard EN13594:2002 (Standardisation, 2002b) does not evaluate the abrasion resistance of the manufactured glove but does address the abrasion resistance of materials used in the gloves individually. A new revision of the standard (currently in publication awaiting approval) has reduced this individual test requirement and will only assess the abrasion resistance of the palm alone.

Motorcycle gloves may be designed with a specific purpose in mind, such as maximum abrasion resistance or maximum impact resistance however this design may come at the cost of suitability for use in day to day motorcycling. A thick, heavy glove will likely provide a high resistance to abrasion, however would also cause significant discomfort during use on a hot day, and is especially unsuited to the high temperature regions of Australia. When setting the standardised levels of protection, a range of potential failure modes need to be considered and ranked, whilst ensuring the levels are set to an achievable goal whilst maintaining thickness and comfort levels.

A test is required that can appraise the abrasion resistance of a fully manufactured glove as it is intended to be worn. This work outlines the design of Cambridge style impact abrasion test for a manufactured glove that will enable in use style appraisal of a gloves resistance to abrasion.

Methodology

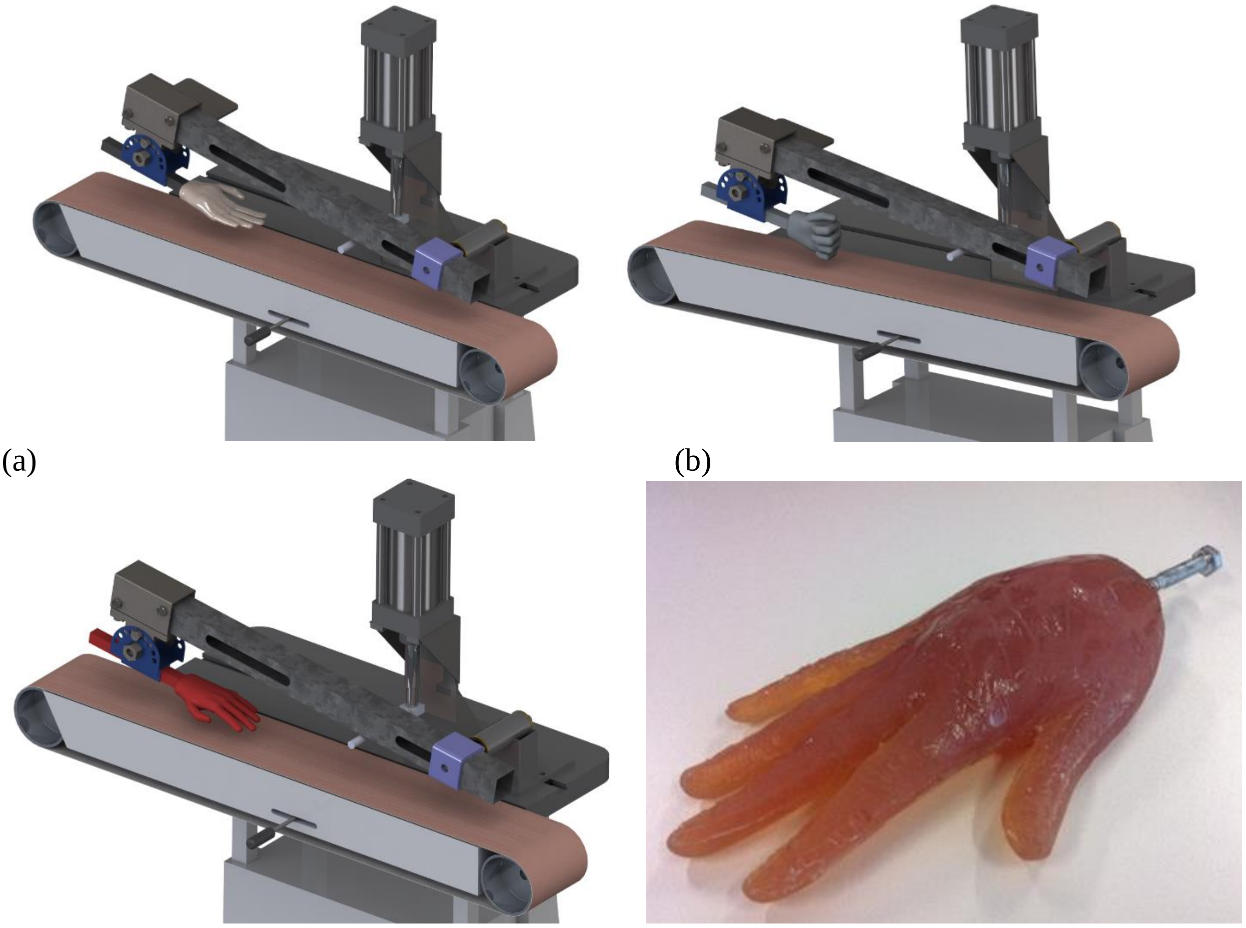
Very limited data has been published on the subject of damage to gloves. A combination of anecdotal information combined with image analysis of damaged glove images posted online after a crash was used to define the test zones of the test rig. Further research is required to improve the quality of this data.

The belt abrasion tester used for this study was based on the Cambridge impact abrasion tester as detailed in the European Standard EN 13595 (Standardisation, 2002a) and the works of R. Woods (Woods, 1996a, 1996b). It was made from a Woodmaster S-80 belt linisher (Hafco, Australia). The belt drive motor had been modified to a 1kW 3 phase motor with a FVR K7S frequency inverter (Fuji Electric, Japan) to enable belt surface speed control of up to 16m/s. The belt was an Vitex KK511X 80grit belt (VSM Abrasives, Germany). The lifting mechanism, on fabric failure, was achieved by a 100mm air actuated ram and the start/drop mechanism utilised a wedged slider acting directly on the abrasion arm. The drop height was interchangable and could be set at any height between 10-500mm. The abrasion arm was fitted so that it could run in the normal mode with a 40mm diameter abrasion surface as well as with the hand so that calibration of the belt using the standard outlined in EN13595-2 could be achieved.

The stop mechanism for the standard test was achieved using a copper break wire as detailed in the standard. The stop mechanism for the hand is still under development and has been detailed further below. The cast hand was developed using Chromax alginate impression material (Barnes, Australia) and F-170 fast set polyeurethane (Barnes, Australia). The 3D printed hand was made from acrylonitrile butadiene styrene polymer (ABS) on a Replicator 2X digital printer (MakerBot Industries, USA).

Results and discussion

The standardized abrasion rig proposed involves an abrasive belt moving at a variable speed, and an arm to drop a glove mounted to a replica hand. A concept drawing of the abrasion tester shows the three test geometries for the abrasion test (Figure 1a-c). The three different proposed positions are: outstretched fingers abrading half of the top of the finger, outstretched palm of the hand and the bottom edge of the curled fist. These test positions have been chosen to simulate abrasion and impact to the area's most commonly exposed in a crash. The outstretched hand allows for the knuckles and, with a slight angle change of the hand, the tops of the finger part of the glove to be evaluated. Knuckle damage often occurs during sliding as hands move around unrestrained. The outstretched palm will measure the palm and lower finger part of the glove that would be damaged by someone putting their hands out to arrest their fall. The bottom edge of the curled fist simulates the side of the hand impacting with the road whilst still holding the hand grip of the handle bars.



(a) (b) (c) (d)

Figure 1. Concept abrasion tester with hand in the position (a) with outstretched fingers and palm up, (b) the bottom edge of curled fist, (c) outstretched palm of the hand and (d) cast polyurethane hand.

A prototype hand replica has been constructed prior to initial testing (Figure 1d). This hand was developed using a dental alginate cast of a size large hand. A polyurethane hand with a shore hardness of 40A was then made inside the alginate preform. A size large hand was selected as this was a common glove size easily obtainable from motorcycle clothing stores. The 40A hardness of polyurethane was chosen as it behaves in a similar manner to a human hand in terms of finger bending stiffness although the indent deflection is much lower with this one hardness model. Further work is required to determine the best indent hardness of the hand.

Initial fit trials with this hand showed problems with the placement of the glove over the thumb and lumps in the palm area that would cause preferential abrasion. To overcome these problems a standard hand has been designed using computer aided design (CAD) based on the dimensions of a size large hand. This hand was designed in a way that the palm of the hand was perfectly flat to enable evaluation of all parts of the palm at one time. It has been produced using a 3D printer out of ABS polymer for initial evaluation. The printed hand is being used for developing the end of test triggering mechanism. Further work will be conducted to ensure that the correct levels of flexure are achieved in the hand model and to investigate articulation of the thumb for ease in putting on gloves.

The initial two hands constructed have been used for initial fit testing, end of test triggering development and as a reference in the development of a mounting system. The final hand model will either be cast from the polyurethane using the ABS hand as the pattern or it will be 3D printed using a variable shore hardness 2 part liquid printer.

The test has been designed to abrade until failure of the protective layer. The wire end of test mechanism utilised by the Cambridge test would be too hard to adopt in a glove so a new stop system needed to be developed. Failure of the external layer will be determined by rupture of an air filled internal nitrile glove. The nitrile glove will be pressurised after the test glove has been fitted prior to testing and sudden loss of air pressure due to rupture will signal the end of the test. The glove would then be raised from the test bed to enable accurate location of the failure point and mechanism. This trigger mechanism is currently under development using the 3D printed hand.

Initial evaluation of this test system has proven positive and should enable the repeatable impact abrasion quantification of already constructed gloves. The evaluation of a fully manufactured glove is important for quality control measurement, standard certification and for a consumer evaluation program (such as a star rating system). The data obtained from this new test procedure should satisfy the requirements of all these end uses. The test should provide more information than the current European standard test as it evaluates impact abrasion effects on both the glove materials and the seams holding the glove together. Currently the test is not operational with wiring of the stop mechanism required before accuracy evaluation can commence. The mass applied to the hand at the different test configurations will need to be evaluated and optimised so that it provides abrasion times similar to those of the calibration standard.

Conclusions

A method for evaluating impact abrasion resistance of a fully manufactured glove has been proposed. The hand model, position of test specimen and test stop mechanism development have been detailed and are close to providing a prototype test device that can be used for test accuracy evaluation. The information obtained from this new test should be suitable for the quantification of fully manufactured gloves for standard certification or use in a rating system.

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