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Performance Comparison of Abrasion Resistant Textile Motorcycle Clothing

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Abstract. Falling at speed onto a tarmac surface during cycling can cause abrasion and laceration of the skin and body tissue. Motorcycle clothing designed to reduce or avoid this type of injury has traditionally been made of animal leather as it has well known resistance to abrasion. In the last 20 years there has been an emergence of textile clothing reinforced with high performance/tenacity fibres such as those made from polyamides, aramids, ultra high molecular weight polyethylene and liquid crystal. Almost no comparative work has been undertaken to provide insight into the level of protection these clothing layers can provide.

This work has used a CE standard test method to evaluate a number of abrasion resistant textile pant products and compare them with a leather race product. It analysed the protective fabric layer structure for mass, thickness, construction method and resistance to abrasion.

Structures manufactured from high tenacity fibres performed better than those from lower tenacity ones. Fabric construction method and mass per unit area were the two key variables in providing an abrasion protective layer. Structures manufactured from knitted para-aramid fibres performed better than their woven counterparts due to the method of fabric failure. Several well designed protective layers performed at a similar level to that of leather; however, most garments tested failed to meet the lower level European standard of abrasion resistance (CE level 1), which may put their wearer at risk in the advent of a collision.

Keywords: motorcycle, abrasion, protective, denim, textile, aramid, liquid crystal polymer.

1. Introduction

Motorcycle use in Australia has been increasing steadily over the last 10 years with a 43% increase seen in motorcycle sales from 2003 until 2011. One of the markets exhibiting rapid growth was scooters and light commuter motorcycles with 176% growth over the 2003-2011 period [1]. As motorcycle use increases so do accident rates. There has been a 14% increase in hospital admissions and 36% increase in emergency department presentations in Victoria alone for on-road motorcyclists between 2003 and 2011 [2]. During the same period, there was a 48% increase in new, on-road bike sales [1]. The average injury cost for a motorcycle casualty ($99,381) in New South Wales is almost double that of the average road casualty ($52,817) [3]. The use of effective personal protective clothing has been shown to reduce this cost and with effective design can be used to reduce the severity of motorcycle injuries [4].

75% of motorcycle crashes happen at or below 50 km/hr [5]. In motorcycle accidents, the leg is the most frequently injured part of the body with between 70-80% of motorcycle accidents involving a leg injury as opposed to 56% for arm and 30-40% for hand and feet/ankles [6]. A large number of the injuries are grazing or gravel rash that is sustained from sliding or rolling along the ground. These injuries can be minimised or avoided by the correct placement of effective protective elements within the clothing of the rider.

Leg protection for riders has traditionally been performed with leather pants or one piece leather riding suits. However, anecdotal evidence from motorcycle apparel shops in Australia suggests the protective denim range now maintains five times or more floor-space than the leather pants. The thermal comfort, flexibility, convenience and look of the denim product are believed to have enabled it to take this level of market share. The method of protection varies from product to product with four distinct fabric types used; woven aramid, double jersey (DJ) knitted aramid, loop knitted aramid and rib knitted aromatic polyester liquid crystal polymer (LCP). Little is known on the protection offered by each of these materials with only products made from the last two achieving CE Level 1 or higher certification.

There are many different ways of testing abrasion in a textile structure with Taber [7], Martindale [8] and impact abrasion testing [9] previously used on motorcycle clothing. Impact abrasion testing has had significant correlation with simulated and emergency department accident damage [10] and is the test apparatus used by the European test method EN 13634:2010 for motorcycle clothing whereas the others provide little correlation with an abrasion incident. Limited information is published on the abrasion resistance of the key lining types of protective jeans with most manufacturers not acquiring CE or other certification.

This study has used an impact abrasion tester to evaluate the abrasion resistance of a number of protective denim products in comparison to leather. It discusses the effect of protective layer structure, fibre type and thickness on resistance to abrasion. These results may be used as a guide for selection of the appropriate level of protection by a consumer.

2. Experimental

2.1 Materials

All fabric samples used in this report were collected from purchased garments. The samples consisted of a plain weave polyamide (PA) fabric (568 g/m^2) removed from a waterproof textile pant, 1.1-1.2 mm leather (1582 g/m^2) removed from a leather pant, a plain weave p-aramid fabric (283 g/m^2) removed from a lined denim pant, a twill weave p-aramid fabric (260 g/m^2) removed from a lined denim pant, a DJ knit p-aramid fabric (413 g/m^2) removed from a lined denim pant, a DJ knit p-aramid/polyethylene (PE) fabric (333 g/m^2) removed from a lined denim pant, 1x1 rib knit aromatic polyester LCP fabric (508 g/m^2) removed from a lined denim pant and a terry loop knit p-aramid/PE fabric (434 g/m^2) removed from a lined denim pant.

2.2 Testing

Abrasion testing was conducted on a LAB belt abrasion tester (Mesdan laboratories, Italy) according to EN13595-1. For each fabric sample, three circular specimens were cut to 160 mm in diameter, tested and the mean value calculated. All samples were removed from the garments so that they did not include pockets, Velcro, trim or embellishments. The layers as arranged in the garment were tested so some tests had only the denim and protective layer, some had an additional inner mesh layer and the LCP had two additional knitted polyester spacer fabrics.

Thickness measurements were conducted using a digital thickness tester (Mesdan Laboratories, Italy). The shoe pressure used was 0.5 kPa and each sample was measured five times. Fabric mass per unit area was measured using a 230/100 mm^2 circle cutter (James Heal, UK) with three specimens measured for each fabric. Fabric mass of the protective layer was done using a 100 mm square sample cut by hand. Thickness and fabric mass measurements were undertaken on individual layers and the thickness and mass of the entire fabric layer assembly calculated.

3. Results and discussions

Figure 1 shows the difference of each of the fabric structures measured. One of the double jersey fabrics was constructed from a mixture of p-aramid and PE with one wale of p-aramid and one wale of PE on the face and a mirror image on the back. The rib terry loop was a mixture of p-aramid and PE in the base fabric with 100% p-aramid in the loop.

The woven fabrics performed the poorest of all of the protective layers tested with results only marginally better than denim by itself (figure 2). The twill weave performed worse than the plain weave and this could be explained by less yarns in contact with the abrasion surface with the twill resulting in higher abrasion loading per yarn and hence faster fabric failure. The difference may also be explained by the thinner denim layer of the original product and the slightly lighter protective layer mass per unit area. The same mass per unit area difference is observed for the DJ fabrics with a heavier denim (260 g/m^2 versus 460 g/m^2) and protective layer (280 g/m^2 versus 330 g/m^2) performing 15% better than the lighter layer.

The LCP fibre resisted abrasion effectively in a structure that would not be expected to perform well. This may be due to the high mass per unit area of the protective layer (509 g/m^2) and also the overall garment mass per unit area (1368 g/m^2) and thickness (7.6 mm). This difference is at least 30% higher for mass per unit area and 50% higher for thickness than the best performing product.

The most effective abrasion resistant layer was the loop structure p-aramid fabric. The reason for the good performance of this fabric was due to the ability for the loop to absorb a large amount of the abrasion impact without significantly degrading the base fabric strength. The other main reason for high abrasion performance was the thickness and mass per unit area for this fabric which was 50% thicker and heavier than the DJ fabrics. The mass normalised results confirm that this structure provides performance similar to leather and is significantly higher than all of the other protective layer types (figure 2).

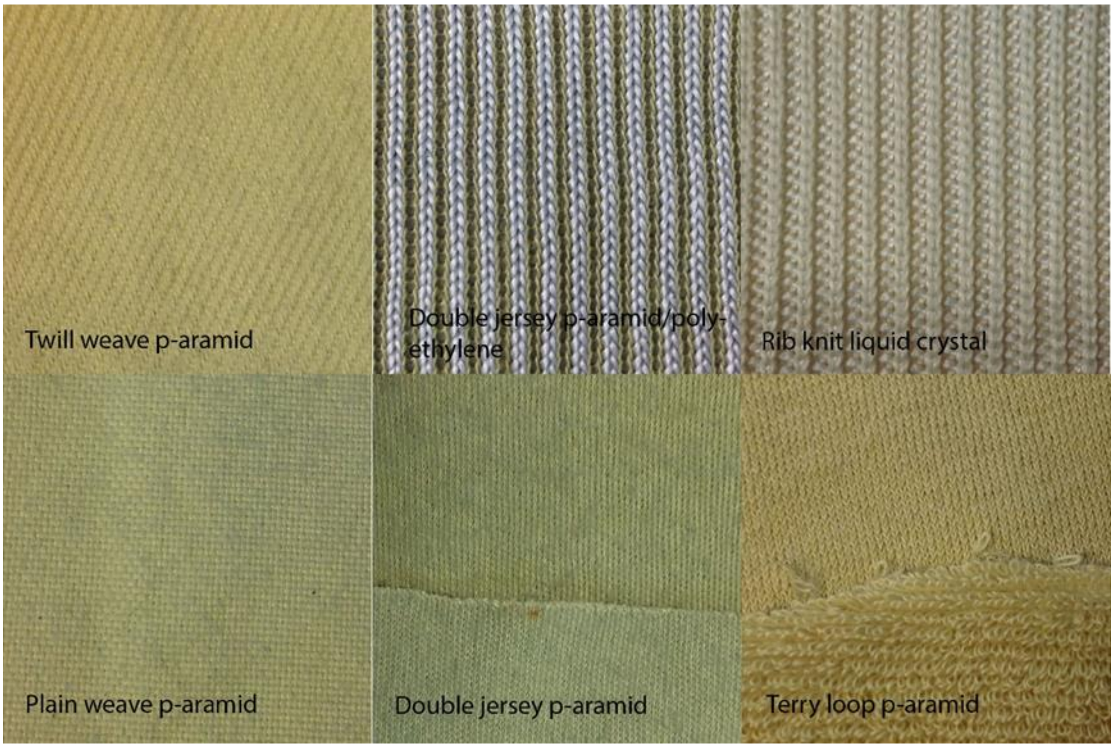

Fig. 1: protective layer fabric structure and fibre type

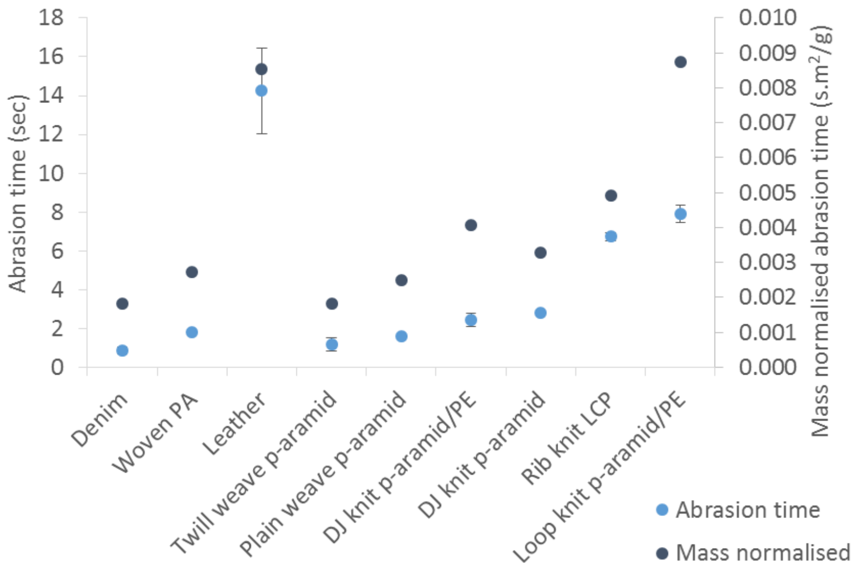

Fig. 2: abrasion resistance results of each fabric structure

The most critical component of abrasion resistance is the amount of material between the body and the road shown by the strong correlation of total fabric mass per unit area with abrasion time (figure 3). The correct protective layer structure can increase the resistance to abrasion and this is indicated by the difference between the loop knit p-aramid/PE structure and the rib knit LCP

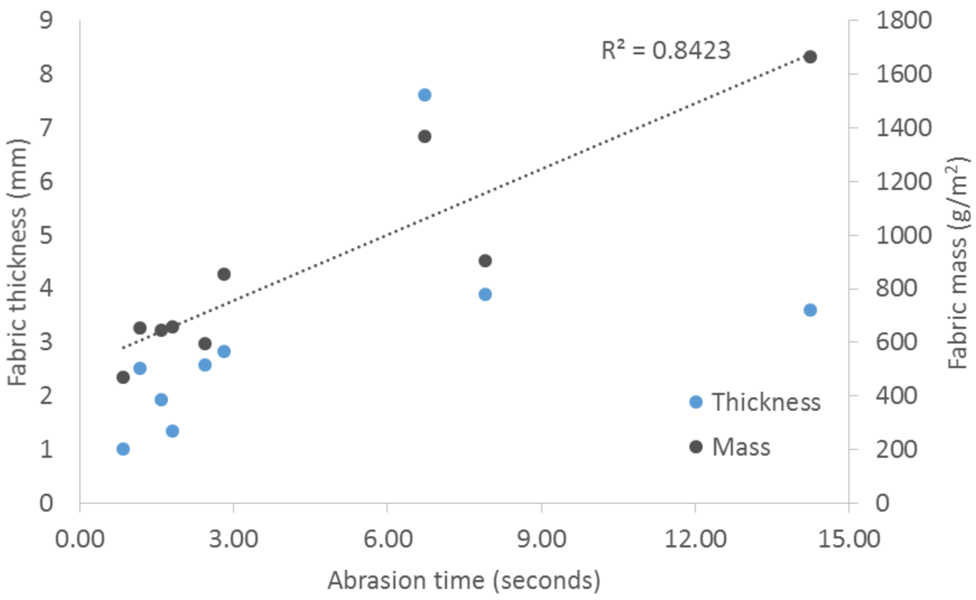

Fig. 3: fabric mass per unit area and fabric thickness with respect to abrasion time

4. Conclusions

Structures manufactured from high tenacity fibres performed better than those from lower tenacity ones. Fabric construction method and mass per unit area were the two key variables in providing an abrasion protective layer. Structures manufactured from knitted para-aramid fibres performed better than their woven counterparts due to the method of fabric failure. Several well designed protective layers performed at a similar level to that of leather; however, most garments tested failed to meet the lower level European standard of abrasion resistance (CE level 1), which may put their wearer at risk in the advent of a collision.

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