DESIGN AND DEVELOPMENT OF SUITABLE YARN COMBINATIONS AND FINE GAUGE HIGH CUT LEVEL INDUSTRIAL GLOVE TO PROTECT HUMAN BEINGS FROM INJURIES DURING INDUSTRIAL WORK

E.R.K.T Perera[1], M.E.R Perera[1*]

[1]Department of Textile & Apparel Technology, The Open University of Sri Lanka

ABSTRACT

The majority of workers may be exposed to a range of occupational hazards at their industrial workplaces, which include cuts and lacerations. Accidents related to the handling of sharp objects account for a considerable percentage of workplace injuries. Generally, cut injuries account for more than 80% of all hand injuries. Therefore, ensuring the safety of workers at workplaces is one of the major requirements in order to avoid occupational injuries. The use of specially designed personal protective equipment is a general practice in such industries. The industrial gloves can be considered as one of the important equipment, which can be used to protect workers against cuts and lacerations.

Three different types of covered yarns were developed by using different yarn combinations in order to produce gloves with fine gauge high cut level for industrial usage. Testing was carried out to check whether developed yarn types were according to the research plan with respect to yarn count, twist per metre and stretchability. Eighteen pairs of gloves were produced by using the three developed yarn types. This included six pairs of gloves from each developed yarn type. The majority of the measurements of the designed and developed gloves were in accordance with the measurements of the selected size chart. The weight of the gloves was between 16.5 grams and 24.5 grams. It was observed that with the increase of the yarn count, the weight of the gloves has increased slightly. The developed gloves were tested for abrasion resistance, blade cut resistance, tear resistance and puncture resistance using the standards EN388. The best performance was shown by the gloves made of yarn type 3, but its weight was the highest (24.5 grams). On the other hand, all the performance results of the gloves made of three yarn types were above the recommended level for industrial gloves, that is Level 3. Therefore any glove made of developed three yarn types can be chosen for high cut applications.

Keywords: Fine gauge, High cut level, Industrial gloves, Occupational injuries, Performance of industrial gloves

[*]Corresponding author: Email – meper@ou.ac.lk

DESIGN AND DEVELOPMENT OF SUITABLE YARN COMBINATIONS AND FINE GAUGE HIGH CUT LEVEL INDUSTRIAL GLOVE TO PROTECT HUMAN BEINGS FROM INJURIES DURING INDUSTRIAL WORK

E.R.K.T Perera[1], M.E.R Perera[1*]

[1]Department of Textile and Apparel Technology, The Open University of Sri Lanka

INTRODUCTION

The majority of workers may be exposed to a range of occupational hazards at their industrial workplaces, which include cuts and lacerations. Accidents related to the handling of sharp objects account for a considerable percentage of workplace injuries. Generally, cut injuries account for more than 80% of all hand injuries. Therefore, ensuring the safety of workers at workplaces is one of the major requirement in order to avoid occupational injuries. The use of specially designed personal protective equipment is a general practice in such industries. The industrial gloves can be considered as one of the important equipment, which can be used to protect workers against cuts and lacerations. Various research has been carried out to design, develop and evaluate industrial gloves used in various industries. In one of the research studies, the comparison of permeation resistance of the protective gloves has been carried out (Chao, et al, 2007). The suitability of cut resistance of hybrid para- aramid has been done on woven protective industrial gloves (Ertekin, et al, 2015). The use of protective gloves on hand performance capabilities such as muscle movement, mastery, contact affectability, finger squeeze and lower arm force have also been investigated (Dianat, et al, 2010). Numerous investigations have shown that gloves may affect manual mastery, material affectability, handgrip strength, muscle movement and exhaustion, and solace ((Dianat, et al, 2012). Tungsten fibres have been used to produce fibre reinforced textile composites to improve the cut resistance of the composites (Gietl, et al, 2018).

Though glove coating technique is applied to improve the performance of gloves, such technique cannot be used to achieve the expected outcome of this research study. It was found that there was a research gap in the development of suitable yarns and gloves with fine gauge and high cut resistance. The purpose of this research was to develop suitable yarn combinations and fine gauge high cut level industrial glove that offers high protection against cuts and lacerations while maintaining the necessary levels of dexterity and comfort required for use in industrial workplaces.

METHODOLOGY

1. A comprehensive literature survey was carried out in relation to the research study.

2. Three different types of covered yarns were developed by using different yarn combinations in order to produce gloves with fine gauge high cut level for industrial usage.

3. Testing was carried out to check whether developed yarn types were according to the research plan with respect to yarn count, twist per metre and stretchability.

4. Eighteen pairs of gloves were produced by using the three developed yarn types. This included six pairs of gloves from each developed yarn type.

5. The developed gloves were tested for abrasion resistance, blade cut resistance, tear resistance and puncture resistance by using international testing standards to evaluate the performance of the gloves made of three different yarn types.

[*]*Corresponding author: Email – meper@ou.ac.lk*

DESIGNING THE EXPERIMENT

Part A: Yarn Development

Yarn development is one of the major activities of this research study. After a comprehensive literature survey and by considering the limitations of the available knitting machines, it was decided to develop three (03) yarn types as per the technical details given in the table 1.

Table 1: Technical details of yarn types

Yarn type	Yarn count (in Denier)	Twist (per metre)	Stretchability (%)
1	380	230	140
2	480	230	140
3	580	230	140

Tungsten, Steel and Spandex were used as core yarns. Tungsten and Steel provide the high cut resistance whereas Spandex provides the fit. High Performance Polyethylene (HPPE) and Nylon were used as cover yarns. HPPE provides the high cut resistance, whereas Nylon provides the comfort. These three yarn types were developed through winding, twisting and covering processes. Table 2 provides fibre types and individual yarn counts used for the yarn development.

Table 2: Fibre types and individual yarn counts used for the yarn development.

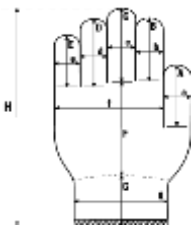
Yarn type	Individual yarn counts of selected fibre types (Denier)				
	Tungsten	Steel	HPPE	Nylon	Spandex
1	75	100	75	1/70	105
2	75	150	150	2/70	105
3	75	100	75	2/70	105

Part B: Glove development

For the development of the gloves, men's size chart of USA was used. Table 3 shows the details of the anthropometric data obtained from the size chart for glove development.

Table 3: Details of the anthropometric data obtained from the size chart for glove development

Size chart (USA -Medium)	Length (mm)	Width (mm)
Thumb	55 (A)	26 (a)
1st Finger	65 (B)	24 (b)
2nd Finger	71 (C)	24 (c)
3rd Finger	67 (D)	23 (d)
4th finger	55 (E)	22 (e)
Upper Palm/ Lower Palm	97 (F)	85 (f)
Wrist	45 (G)	72 (g)
Total Length	213 (H)	N/A



The gloves were developed by using 18 gauge, flatbed, v shaped fully automated glove knitting machine. The selected machine parameters used for glove knitting are given in table 4.

Table 4: Selected machine parameters used for glove knitting

Machine gauge (gg)	18
Machine speed (rpm)	210
Machine size	L2
Loop length	4.1
Courses (Yarn Type 1)	70,92,108, 88,46, 70,52,88
Courses (Yarn Type 2)	70,92,106, 88,44, 70,50,88
Courses (Yarn Type 3)	72,94,108, 88,50, 70,50,86
Elastic yarn setting	1/1 (Machine Setting 2/1)

Part C: Testing the developed yarns and gloves

Yarn testing was carried out to check whether developed yarn types are according to the research plan with respect to yarn count, twist per metre and stretchability. The developed gloves were tested for abrasion resistance, blade cut resistance, tear resistance and puncture resistance by using international testing standards EN 388 to evaluate the performance of the gloves made of three different yarn types.

DATA COLLECTION AND ANALYSIS

Part A: Yarns

The developed yarn types were evaluated for yarn count, twist per metre and stretchability and the values are given in table 5.

Table 5: Test results of the developed yarns

Yarn type	Expected yarn count (in Denier)	Actual yarn count (in Denier)	Expected twist per metre	Actual twist per metre	Expected stretchability (%)	Actual stretchability (%)
1	380	432	230	230	140	140
2	480	504	230	230	140	140
3	580	612	230	230	140	140

As per the test results, it was observed that the measured values of the twist and the stretchability were similar to the expected values in the research design. The measured values of the yarn counts showed slight variations. The count variations in percentages for yarn types 1, 2 and 3 were 13.66, 5.00 and 5.5 respectively. The accepted variation of yarn counts in glove manufacturing is below 20% and the yarn count variations of the developed yarns were within the acceptable limit.

Part B: Gloves

The developed gloves were first measured for the dimensions. The results are given in table 6.

Table 5: Actual dimensions of the developed gloves by using three yarn types

Measurement	Gloves made of yarn type 1		Gloves made of yarn type 2		Gloves made of yarn type 3	
	Length (mm)	Width (mm)	Length (mm)	Width (mm)	Length (mm)	Width (mm)
Thumb	55 (A)	26 (a)	55 (A)	26 (a)	55 (A)	26 (a)
1st Finger	65 (B)	24 (b)	65 (B)	24 (b)	65 (B)	24 (b)
2nd Finger	71 (C)	24 (c)	71 (C)	24 (c)	71 (C)	24 (c)
3rd Finger	67 (D)	23 (d)	67 (D)	23 (d)	67 (D)	23 (d)
4th finger	55 (E)	22 (e)	55 (E)	22 (e)	55 (E)	22 (e)
Upper Palm/ Lower Palm	97 (F)	85 (f)	97 (F)	85 (f)	97 (F)	85 (f)
Wrist	50 (G)	80 (g)	50 (G)	88 (g)	50 (G)	96 (g)
Total Length	215 (H)	N/A	218 (H)	N/A	225 (H)	N/A

Figure 1:Developed glove

As per the results, it was found that all the measurements, except the wrist and the total length, are in accordance with the measurement in the size chart. There were deviations in the measurements of wrist and the total length. Those variations were within the acceptable limits of glove manufacturing. The weight of the gloves was also determined are shown in the table 6.

Table 6: Actual dimensions of the gloves developed by using three yarn types

	Gloves made of yarn type 1	Gloves made of yarn type 2	Gloves made of yarn type 3
Weight (g)	16.5	19.5	24.5

As per the results, it was observed that with the increase of the yarn count, the weight of the gloves has been increased slightly.

The developed gloves were also tested for performance by using the standards EN388. The results are given in-table 7.

Table 7: Performance of the gloves

Glove type	Test (results are indicated in Level)			
	Abrasion resistance	Cut resistance	Tear resistance	Puncture resistance
Gloves made of yarn type 1	3	5	4	3
Gloves made of yarn type 2	3	5	4	3
Gloves made of yarn type 3	4	5	4	4

For industrial gloves, the recommended minimum Level for above tests is Level 3. As per the test results, it is apparent that all the developed gloves have achieved the required level of performance.

C**ONCLUSION**

This research study was carried out to design and develop suitable yarn combinations and new fine gauge high cut level industrial glove to cater to the demand of fine gauge industrial glove market. In the current glove market, the available gauges of gloves lie between seven (7) and thirteen (13). In order to improve the fineness, gauge eighteen (18) was selected for this study. The developed three yarn types were used to design the fine gauge high cut level industrial gloves. The majority of the measurements of the designed and developed gloves were in accordance with the measurements of the selected size chart. The weight of the gloves was between 16.5 grams and 24.5 grams. It was observed that with the increase of the yarn count, the weight of the gloves has increased slightly. The developed gloves were tested for abrasion resistance, blade cut resistance, tear resistance and puncture resistance using the standards EN388. The best performance was shown by the gloves made of yarn type 3, but its weight was the highest (24.5 grams). On the other hand, all the performance results of the gloves made of three yarn types were above the recommended level for industrial gloves, that is Level 3. Therefore any glove made of developed three yarn types can be chosen for high cut applications. This research study was conducted as a preliminary study and further studies should be carried out to validate the outcome by using an increased number of samples.

REFERENCES

Chao, K.P., Lai, J.S., & Lin, H.C., (2007). Comparison of permeation resistance of protective gloves to organic solvents with ISO, ASTM and EN standards methods. Polymer Testing 26, 1090-1099.

Dianat, I., Haslegrave, C.M., & Stedmon, A.W., (2010). Short and longer duration effects of protective gloves on hand performance capabilities and subjective assessments in a screw-driving task. Ergonomics vol.53, No.12, 1468-1483.

Dianat, I., Haslegrave, C.M., & Stedmon, A.W., (2012). Methodology for evaluating gloves in relation to the effects on hand performance capabilities: A literature review. Ergonomics vol.55, No.11, 1429-1451.

Ertekin, M., & Kirty, H.E., (2015). Cut resistance of hybrid para-aramid fabrics for protective gloves. The journal of textile institute vol. 107, No. 10, 1276-1283.

Gietl, H., Mueller, A., Coenen, J.W., Decius, M., Ewert, D., Hoschen, T., Huber, P., Milwich, M., Riesch, J., & Neu, R. (2018). Textile preforms for tungsten fibre-reinforced composites. Journal of composite materials 0(0), 1-10.