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Cut Resistant Performance of E-Glass Reinforced Para-Aramid Gloves with Repeated Laundering and Industrial Use

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Abstract: Protection of human body is not a new concept. There are so many type of protection available to protect human body but protection by clothing is one of the most effective ways to protect the human body.There are not only the environmental conditions which human body needs to protect from, but every person has to deal with chemical, mechanical, biological and radiation hazards at their work place. No danger or risk can be completely eliminated via any meansbut injuries takes place at workplace due to these risks can be reduced upto many extent by using appropriate protective clothing. Cut-resistant clothes are available in the form of gloves, caps, sleeves, body armour, etc. Gloves and forearms are used to protect human hands against mechanical and thermal risks such as broken glasses, metal shards, razor sharp machinery, molten metal splashes, etc involved during performing task at workplace. Cut protective clothing ismanufactured using high performance fibres (e.g. aramids, high performance polyethylene, polyamides) and their blends with reinforcement of multifilament materials such as e-glass, aramid, basalt, stainless steel, etc.

The present study emphasises on the effect of repeated laundering and industrial use on performance of cut resistant properties of* e-glass reinforced para-aramid gloves*. Cut resistant properties of these gloves were analysed as per test standard EN 388:2003. In concern to repeated laundering, gloves were laundered for 10 and 20 times in IFB fully automatic washing machine. Further, cut resistant performance of these gloves after regular use in welding workshop and building construction industry was assessed. The result of the study shows that the Para-Aramid gloves provide excellent level of cut protection which is durable even up to10 and 20 laundering cycles and even after regular use in industries for 10 days.

Key Words: Protective clothing, Cut resistance gloves, reinforced, Para-Aramid, E-glass, laundering

I. INTRODUCTION

Every type of clothing protects human body by some means but protection against some special conditions such as fire, mechanical hazards, cold, bacteria, chemicals etc. needsspecific protective clothing. Protective clothing is the specially designed clothing which protects human body from harsh climatic conditions or from various work hazards existing at work place. No one can ignore or eliminate the risk available at work place but reduction of body injury is possible by using appropriate personal protective equipments. Therefore,personal protective clothing is designed as per the desire properties required according to the danger or risk a worker have to deal with. Level of protection provided by the protective clothing is depends upon the design, structure and construction of personal protective clothing. Injuriesto hands constitute a considerable shareof the total number of accidents. These injuries can be eliminated or reduced by use of protective gloves [1]. Though there is no glove which can provide 100% protection to human hands from all hand injuries, therefore various types of gloves with different composition are manufactured to provide various types of properties in gloves for protection according to the priority of safety and risk available.

Out of all categories of protective gloves, demand for cut resistant gloves is mushrooming day by day as approximately, 80% of all hand injuries occurred due to cuts with sharp protruding or moving objects. Therefore there is a massive requirement of protective gloves which not only resist cuts but also comfortable to wear and according to trend [2].Basic properties required in cut resistant materials are cut resistance, tear strength and abrasion resistance as well as grip ability and dexterity to wearer [3, 4].Hand protection varies from industry to industry and they come in various products like gloves, arms and forearms, protective sleeves, etc made from separate materials designed to confirm the best protection against the specific hazards [5]. Cut resistant gloves are very much suitable for glass, construction, welding, meat cutting industries, etc [6].

The cut resistant gloves can be manufactured from high performance fibre alone or in association with traditional fibres. In present investigation performance study with repeated laundering and industrial use of e-glass reinforced with para-aramid gloves were

analysed. Para-Aramid fibres are also termed as Kevelar fibres.It is extremely strong, lightweight, corrosion and heat resistant. Aramid fibre is produced by the dry-jet, wet spinning method resulting in a fibre which consists of fully extended liquid crystal chains formed along the its axis with a high degree of crystallinity. This causes the polymer chains to orient in the direction of the fibre and increasing the fibre strength[7]. It behaves elastically under tension. When it comes to severe bending, it shows non-linear plastic deformation[7]. Aromatic nature of para-aramid is responsible for oxidative reactions when exposed to UV light that leads to a change in colour and loss of some strength[7]. Kevlar, because of its high tensile strength-to-weight ratio, has many applications, ranging from bicycle tires and racing sails to body armour. Also it is 5 times stronger than steel[8,10]. The e-glass fibres were chosen for reinforcement as they are extremely fine, light weight, extremely strong, electrically insulator and robust. E-glass fibre is also being used in thermal insulation, electrical insulation, sound insulation, high-strength fabrics or heat and corrosion-resistant fabrics [9]. Commercially, e-glass is a cost effective solution in comparison with reinforcement with ss wire.

The repeated laundering and continual use of protective clothing in work place affects its durability [11-13]. Therefore, the first part of study involves checking the durability of gloves after repeated laundering for 10 and 20 times and second part of study involveevaluating durability after regular wear in industries for 10 days. In first study, fully automatic IFB machine was used to wash the samples to solve the purpose of home laundering. In concerned to second part of study, samples were supplied to the local industries like building industry, welding industry, etc for industrial use. Further durability of gloves was examined by visual appearance and change in colour, weight loss and EN 388 testing standards. The current finding is restricted to the liners only, further research is being carried out to develop palm coating /dipping of these liners with latex and nitrile rubber compounds.

II. EXPERIMENTAL PROCEDURE

A. Materials

High performance knitted e-glass reinforced para-aramid gloves (Fig.1), complementarily given by High Performance Textile Pvt. Ltd, Panipat, Haryana, India were used for the study with following specifications:

1) *Para-Aramid reinforced with E-glass:*Para- Aramid reinforced with e-glass glove is manufactured by using Para-Aramid fibres and E-glass in core which are inherent flame-retardant and cut in nature.
2) *Composition:*Para-Aramid (400 denier) with E-glass (200 denier) in core;
3) *Gauge:* 7G (2 ply),
4) *Sizes:* 14''

Figure 1: Photographs ofHigh performance knitted e-glass reinforced para-aramid gloves

Detergent Used: Commercially available washing detergent i.e. Tide® was used for washing.

B. Machines used

IFB 7 Kg Elite Aqua VX 1000 RPM Fully Automatic Front Load Washing Machine

Laundering was done on IFB fully automatic machine according to standard EN:61456/ICE:60456. Gloves samples were laundered for 1 hour 6 minutes and allowed to dry at 40°C. In the same way laundering process was repeated for 10 and 20 washes.

C. Procedure to check durability of sample gloves

The change in appearance and durability of gloves after repeated laundering and regular use in industry was determined in following ways:

1) A visual comparison was carried out between the washed-unwashed and used-unused gloves samples[12,13].
2) Change in colour of gloves before and after wash by using CCM was analysed.
3) Weight of gloves before and after wash was analysed.
4) Testing of gloves samples was carried out according to EN308:2003 standard: (for Cut resistant gloves).

D. Testing standard for cut resistant gloves: EN388:2003

This standard specifies that the gloves are intended to give protection against mechanical hazards. This standard involves testing of resistance to abrasion, blade cutting, tearing and puncture resistance as follows [11].

1) Abrasion Resistance: The material of the glove is abraded with sand paper under pressure and the number of cycles required to wear a hole in the material is measured. The highest performance level is 5, which corresponds to 8,000 cycles.
*2) Resistance to cutting*The test involves measuring the number of cycles required for a circular knife rotating at constant speed to cut through the test specimen. The highest performance level is 5, which corresponds to an index of 20.
3) Tear resistance: An incision is made in the test specimen. The amount of force required to tear the material apart is then measured. The highest performance level is 4, which corresponds to a force of 75 N.
4) Puncture resistanc: The test involves measuring the amount of force required to pierce the test specimen with a standard sized point and at a given speed (10cm/min). The highest performance level is 4, which corresponds to a force of 150 N [11].

III. RESULTS AND DISCUSSIONS

A. Visual appearance and change in colour

Visual comparison between washed and unwashed samplesas well as used and unused samples was carried out. The gloves have compact knitting structure before washing but it can be observed from Fig. 2 that with repeated washes negligible fuzzy appearance noticed on gloves surface as loose fibres protrude and entangled with each other during laundering operation.

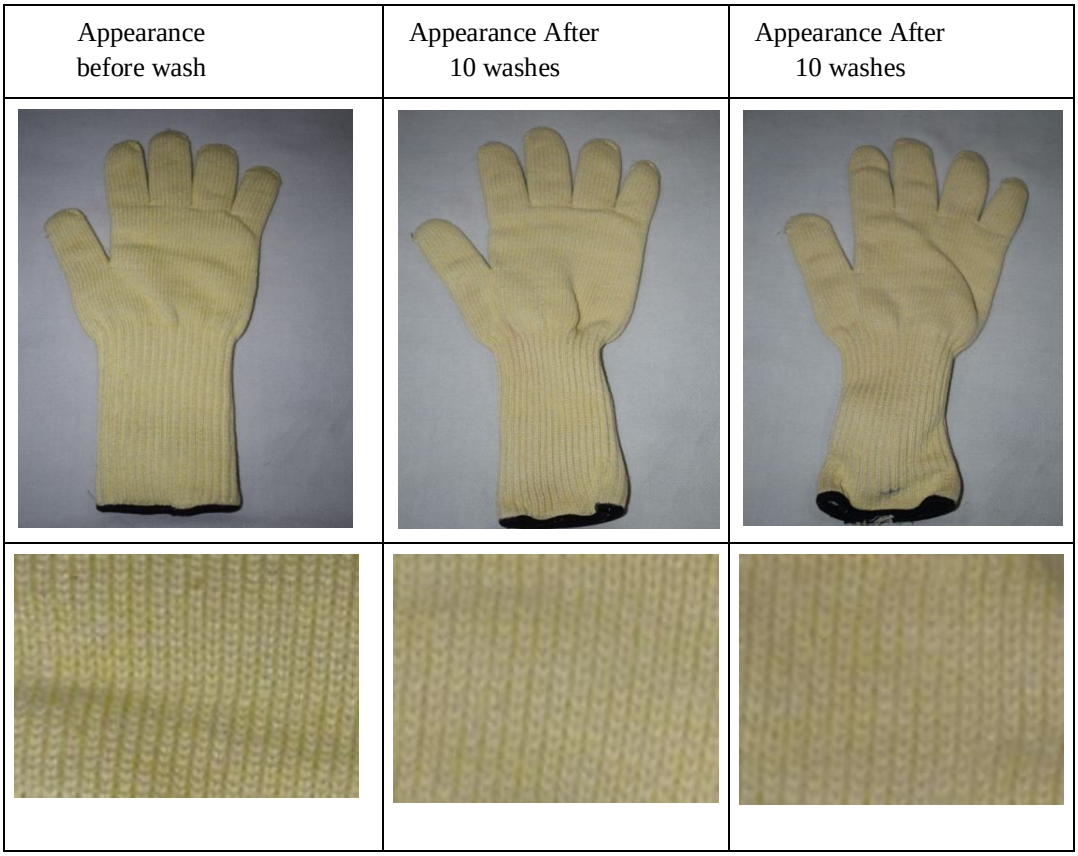

Fig 2: Photographs ofe-glass reinforced para-aramid gloves sample before and after washing

The colour values of laundered and unlaundered e-glass reinforced para-aramid gloves was determined and colour difference values are indicated in Table 1. It can be observed that the significant large negative △b values shows that shade of e-glass reinforced para-aramid gloves changes towards bluish side after repeated laundering.

Colour difference	Δl	Δa	Δb
After 10 washes	-2.98	1.14	-13.18
After 20 washes	3.79	0.57	- 15.64

Table 1: Colour difference values of repeated laundered E-glass reinforced Para-Aramid gloves before and after washing by using CCM

The appearance of gloves after use in various industries is shown in Fig 3. It can be observed from figure that with continual industrial use compact knitted structure slightly loosen. The foreign metal particles, soiling substances like rust particles associated with industries also stained the gloves surface during their use in welding industry. Similarly dirt and dust is adhered on gloves surface during use of gloves in buildingconstruction industry. Overall after continual use, gloves become soiled with various foreign particles associated in industry and its environment.

User 1- Welding workshop; User 2- Building construction

Figure 3: Photographs of E-glass reinforced Para-Aramid gloves before and after industrial use

B. Weight Measurement

The weight of laundered gloves was determined and shown in table 2. It can be observed from the table 2 that there is slightly reduction in weight of gloves after 10 and 20 washes of glove samples. The negligible decrease in weight indicates that structure of gloves is stable.

Weight of gloves before wash	Weight of gloves after 10 washes	Weight of gloves after 20 washes
330.15 g	329.1 g	328 g

Table 2: Weight of e-glass reinforced para-aramid gloves before and after wash

C. Experimental testing according to the standards: EN308:2003

The cut resistance properties in terms of abrasion resistance, blade cut resistance and tear resistance of E-glass reinforced Para-Aramid gloves were determined after repeated laundering and use in various industries as shown in Table 3.

Sr. No.	Test Parameter	Unit	Test results before wash and use		Test results after 10 washes	Test results after 20 washes	Test results after user 1	Test results after user 2
			Test results	Level achieved	Level achieved	Level achieved	Level achieved	Level achieved
1.	Abrasion resistance :	No. of cycles	Breakdown observed up to 8000 rubs	3	3	3	3	3
2.	Blade cut resistance	Index	64.07	5	5	5	5	5
3.	Tear resistance across length		>75	3	3	3	3	3
	Tear resistance across width		>75	3	3	3	3	3

User 1- Carpenter workshop; User 2-Floor construction

Table 3: Performance level achieved by the E-glass reinforced Para-Aramid gloves before and after washing as well as before and after industrial use.

It can be observed from above table 3 that e-glass reinforced para-aramid have good cut protection properties being high level of abrasion, blade cut resistance and tear resistance value of 3, 5 and 3, respectively. The e-glass reinforced para-aramid gloves also shows excellent durability in cut protection properties even after repeated 10 and 20 washes and after industrial use being

no change in level of abrasion, blade cut resistance and tear resistance value. This is mainly due to high strength, abrasion resistant high performance para-aramid (400 denier) and e-glass (200 denier) in core which are cut and heat resistant in nature.

IV. CONCLUSION

The results of the study show that e-glass reinforcedpara-aramid gloves can be used efficiently for cut protection as per EN308:2003 standard in various industries. These gloves exhibit cut protection properties even after repeated laundering up to 10and 20 cycles as well as continuous use in various industries. There are only some bearable changes in aesthetic properties such as change in colour, soiling and slight increase in fuzziness on surface of these gloves after repeated laundering as well as continual use. It can be concluded that being cost effective, the use of e-glass reinforced para-aramid gloves can be explored further on the basis of performance in cut protective clothing applications.

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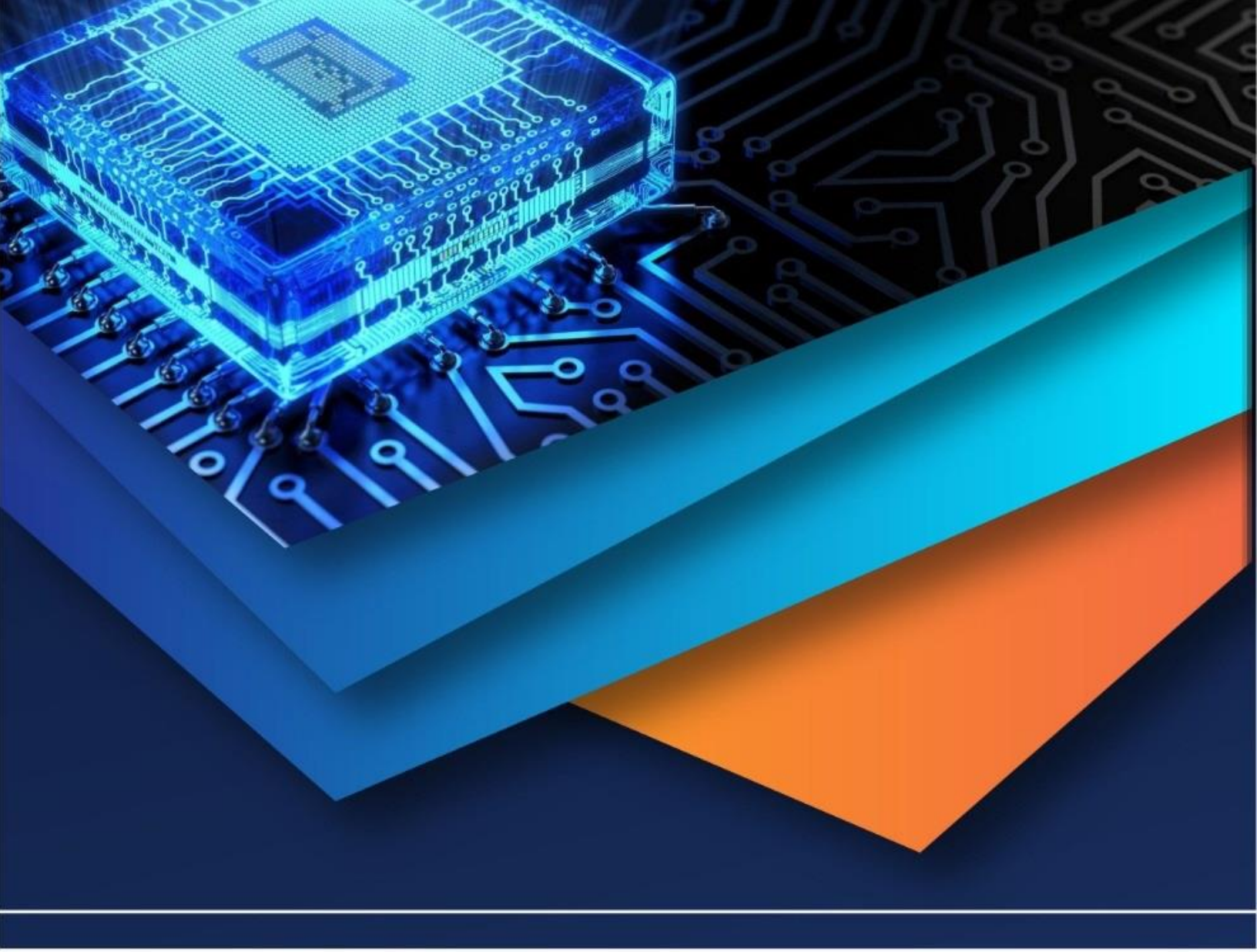

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