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Heat Protection Performance of E-Glass Reinforced Para-Aramid Gloves after Repeated Laundering and Continual Industrial Use

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Abstract: Protective textiles plays pivotal role in safe guarding the human body against the risks associated with mechanical, chemical, bio-logical, radiation, etc hazards. Heat protective gloves are used for protection of hands against high temperature, spark, flame, molten splash, etc hazards and provide suitable handling of hot, rough and sharp metal objects. These heat protective gloves are manufactured from high performance fibres such aspara or metaaramid, e-glass, modacrylic, carbon, etc.
In present investigation heat protection performance of indigenous manufactured e-glass reinforced para-aramidgloves was studied. Heat protection performance of gloves was also studied after 20 repeated washing and regular use in various industries like welding, building construction, etc.In experimental procedure, the durability performance of gloves wasanalysed via visual appearance, change in colour, weight loss and EN 407:2004 testing standard. The finding of the results shows that e-glass reinforced para-aramid gloves have excellent heat protection withdurability to repeated laundering up to 20 cycles and continual industrial use.
Keywords: Protective textile, Heatresistant, Para aramid, e-glass, CCM

I. INTRODUCTION

Protection of the body during daily activities as well as in specialty task is the main concern. Therefore various types of protective articles have been designed for safety purpose of the human body. [1-2]Protective textiles are a part of technical textiles which have to fulfill required technical performance needed for protection instead of aesthetic and decorative aspects as priorities. Protective textiles provide solutions for the technical challenges like environmental protection, personal safety, general safety, health, etc. These textiles protect the wearer from harsh conditions that may results in injury or death. Protective garments that provides protection from various hazards may be mechanical, environmental pressure, thermal, fire, chemical, biological, electrical, radiations, etc.[3,4]

Arm can be protected from injuries by applications of suitable protective gloves and sleeves that cover the entire arm or just parts of the arm.[1-2]Gloves and sleeves are manufactured from various types of textile raw material as per the requirement. The heat resistant clothing for hand protection has great market. Heat resistant ornon-flammable textile materials is required in manufacturing of protective textile for protection against convective (flames), radiative and contact heat, against sparks and drops of molten metal.[1-2] Besides flame retardant properties they must also have ability to reduce the heat transfer from a high temperature source, either by direct contact (conduction/ convection) or via radiation.[5]Kevlar, ceramic, glass, para-aramid, carbon, etcfibre alone or in combination are extensively used in heat protective clothing as they can withstand extreme temperatures without melting.[6,7]It is essential that heat resistance gloves must not change their protection properties and durability in spite of repeated laundering and continual use in even adverse conditions.[8,9]

Para-aramid fibre has been chosen as raw material in studied gloves being its high tensile modulus, high heat resistance, highly oriented rigid molecular structure and appropriate elasticity.[10]Para-aramid is an aromatic polyamide manufactured by dry-jet, wet spinning methodresulting in a fibre which consists of fully extended liquid crystal chains formed along the fibre axis with a high degree of crystallinity which increases the fibre's strength.[11]Further, e-glassfibres have been used for reinforcement of para-aramid being its high electrical insulating,low moisture regain, high mechanical properties along with low price.[12]In present investigation, indigenously manufactured e-glass reinforced para-aramid gloves were studied for their heat protection properties with repeated laundering and continual use in various industries.

II. EXPERIMENTAL PROCEDURE

A. *Materials*

1) *Gloves used***:** Heat resistant gloves (Fig. 1), complementarily given by High Performance Textile Pvt. Ltd, Sonepat, Haryana, India was used for the study with following specifications:
2) *Raw material:*Para-aramid with E-glass reinforcement
3) *Composition***:**Para-Aramid (400 denier) with E-glass (200 denier) in core;
4) *Gauge:*7GG (2 ply)Sizes: 14''

Figure 1: Para-aramid with E-glass gloves samples

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 was used for laundering purpose. Laundering was done on IFB fully automatic machine according to standard EN: 61456/ICE: 60456. In each laundering cycle, glove samples were washed and rinsed for 1 hour 6 minutes and then allowed to dry at 40°C. This laundering process was repeated again till 10 and 20 wash cycles.

C. Performance evaluation ofheat protection property ofe-glass reinforced para-aramid gloves against repeated laundering and repeated use

In first part of study, durability of heat protection property of e-glass reinforced para-aramid gloves was evaluated after 10 & 20 repeated laundering. In second part of study, durability of heat protection property of e-glass reinforced para-aramid was evaluated after use of gloves for 10 days in various industries. Fully automatic IFB machine was used to wash the samples to solve the purpose of home laundering. Whereas for second part of study, gloves samples were supplied to the local industries like welder, building constructor, etc for industrial use. Gloves were examined by visual appearance, change in colour, weight loss and EN 407:2004 testing standards. The EN 407:2004 standard specifies thermal performance of protective gloves in relation to heat and/or fire generated as a result of combustion, radiation or molten metal, spark, etc.

D. Procedure to check durability of gloves

The change in appearance and physical properties of gloves was determined as follows:-

1) Visual appearance of washed and unwashed as well as industrial used and unused gloves.
2) Change in colour after laundering.
3) Weight loss.
4) Testing of sample gloves according to EN 407:2004 standard.

E. EN 407:2004 standards[13]:

The EN 407:2004 standards cover several parameters as follows

1) *Resistance to burning behaviour:*-In this test, time is measured for the glove material to stop burning and glowing after being exposed to a gas flame for 15 seconds. The highest performance assigned level is 4, which represents an after burn time of no more than two seconds and an afterglow time of no more than five seconds. If the glove risks coming into contact with fire, it must attain at least Level 3
2) *Contact heat resistance:*- The test involves measuring the temperature range (100°C–500°C) at which the glove gives protection for 15 seconds without the inside of the glove becoming ten degrees hotter. The highest performance level is 4, which means the glove can withstand + 500°C

3) *Convective heat resistance:-* This is based on the length of time the glove is able to delay the transfer of heat from a flame to the extent that the temperature on the inside increases by 24 degrees. The highest performance level is 4.
4) *Radiant heat resistance:-* The glove is exposed to heat radiation. The test involves measuring the time it takes for a given amount of heat to penetrate the glove. The highest performance level is 4, which means that the glove gives protection for at least 95 seconds.
5) *Resistance to small splashes of molten metal:-* The test involves measuring how many drops of molten metal are needed to increase the temperature between the glove material and the skin by 40°C. The highest performance level is 4, which corresponds to 35 drops or more.
6) *Resistance to large quantities of molten metal:-* This test shows how many grams of molten iron are required to damage synthetic skin (PVC) attached to the inside of the glove material. The highest performance level is 4, which corresponds to 200 grams of liquid metal.

III. RESULTS AND DISCUSSIONS

A. Para-aramid with E-glass gloves

*1) Visual Comparison and change in colour:*Visual comparison between unwashed and washed, industrial unused and used e-glass reinforced para-aramid gloves samples was carried out. It was observed that before washing gloves have compact neat and clean knitted structure but after 20 repeated laundering there was slight fuzzy appearance due to entanglement of protrude fibres on gloves surface and slightly loosened the structure.

Colour difference values after	△l	△a	△b
10 washes	-2.98	1.14	-13.18
20 washes	3.79	0.57	- 15.64

Table 1: Colour difference values of repeated laundered e-glass reinforced para-aramidgloves.

The change in colour after the repeated laundering was measured by Computer Colour Matching system and differences in colour values are shown in Table 1.It can be observed that change in “l” and “a” values were less as compared to change in “b” values. The significant large negative △b values shows that shade of e-glass reinforced para-aramid gloves changes towards bluish side after repeated laundering.

The e-glass reinforced para-aramid gloves were used in welding industry and building construction for ten days. Their visual appearance after use is shown in Fig. 2. It can be analyzed from the figure that some rust particles were adhered on gloves surface after used in welding industry as well as some dirt and dust particles were also stained the glove surface after used in building construction. The results show that gloves have good stability during applications in various industries.

Appearance of e-glass reinforced Para-aramid gloves before use	Appearance of e-glass reinforced Para-aramid gloves after use in the welding workshop	Appearance of e-glass reinforced Para-aramid gloves after use in building construction
		

Figure 2: e-glass reinforced Para-aramid gloves samples before and after industrial use

2) Weight Measurement: weight of laundered e-glass reinforced para-aramid gloves is shown in Table 2. It can be observed from the table that there is slight reduction in weight of gloves after washing of glove sample.

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

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

3) Testing of e-glass reinforced para-aramid gloves according to the standards: EN 407:2004
The e-glass reinforced para-aramid glovessamples were tested as per EN 407:2004 standards and obtained results are shown in Table 3.

S.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 (Welder)	Test results after user 2 (Building constructor)
			Test results	Level achieved	Level achieved	Level achieved	Level achieved	Level achieved
1.	Burning behaviour (flame applicable at edge)	-	-No after flame -No after glow -No melting and dripping -No seam opening	4	4	4	4	4
2.	Contact heat	Sec.	21.7 at 250° contact temp. 13.5 at 350° contact temp.	2	2	2	2	2
3.	Convective heat	Sec.	Lowest 28.5	5	5	5	5	5
4.	Radiant heat	Sec.	Lowest 46.8	2	2	2	2	2

It can be observed from Table 3 that e-glass reinforced para-aramid gloves provide excellent heat protection after being used in welding industry as well as also provide protection during handling of building construction material.The gloves retain their heat protection properties intact as it is without losing performance level of the entire four test parameters even repeated laundering for 20 cycles.

IV. CONCLUSION

The finding of the study shows that e-glass reinforced para-aramid gloves can be used efficiently for heat protection as per standard EN407:2004 in various industries. These gloves exhibit good dimensional as well as heat protection properties even after repeated laundering up to 20 cycles as well as continual use in various industries.Thus, e-glass reinforced para-aramid gloves can be used efficiently in protection of hands in various industries associated with fire are related hazards.

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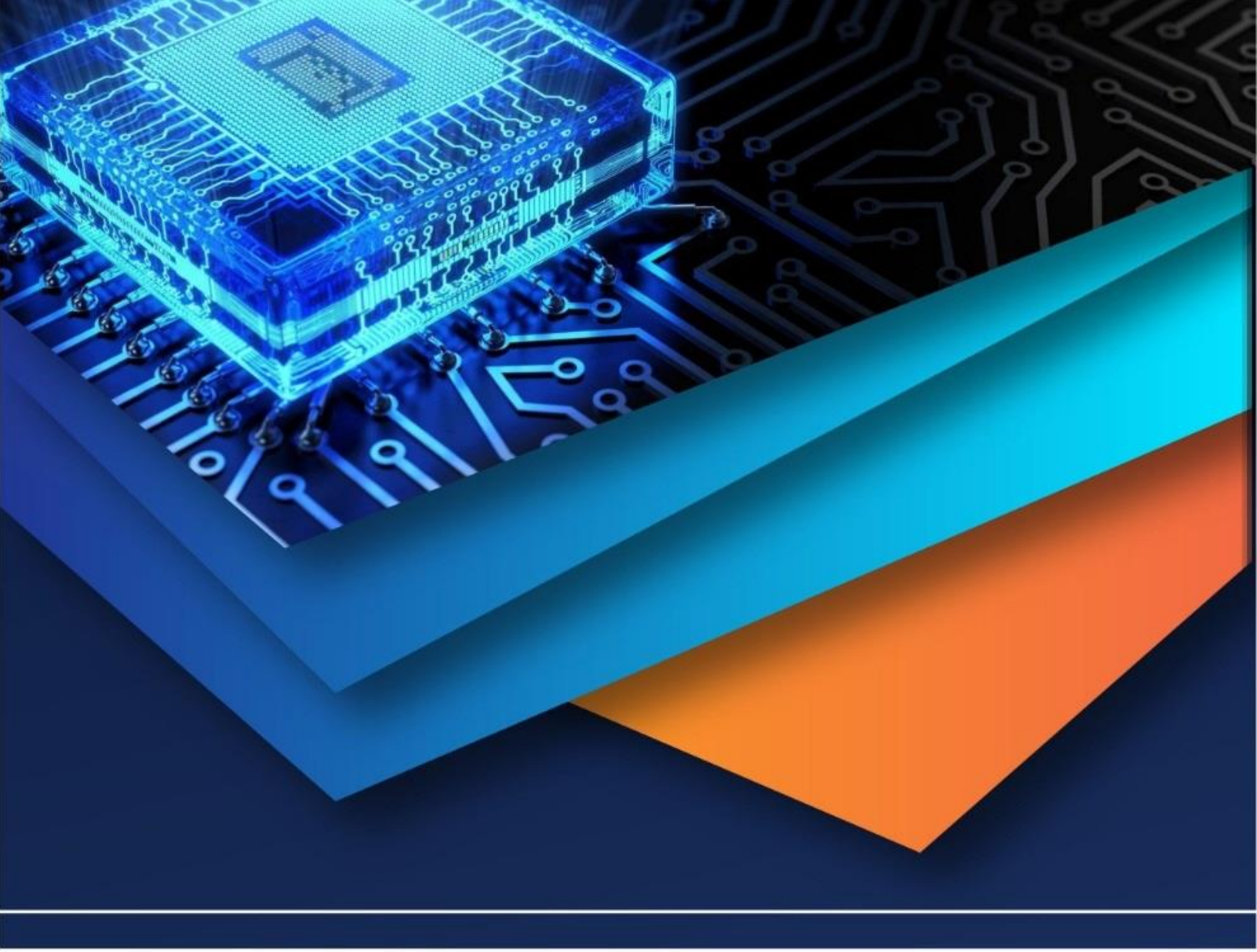

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