Effect of Finishing Treatment on Micro Polyester for Chemical Resistant Work Wear

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Abstract:

In India there are many Industries using or processing various chemicals. One such industry where chemicals are utilized is Electroplating Industry. This industry mostly comprises of small-scale units where workers employed do not wear any kind of Protective Clothing and handle Chemicals wearing normal clothing. In fact, it is a well-known fact that in most of the chemical industries, workers are in direct contact with chemicals. Electroplating Industry is one such industry where workers handle hazardous chemicals. The basic electroplating employs a plating bath filled with water containing a small amount of acid or alkali added to improve its conductivity [1]. *A wide variety of chemicals and substances are used, depending on the surface properties of the objects to be electroplated. All textiles serve various needs such as modesty, functional and aesthetics. The need of protection is of utmost importance. Textiles protect the body from various hazardous conditions in which man has to work. A chemical accident is the unintentional refuse or spill of one or more hazardous substances which can harm human health or the environment. Personal Protective Equipment, or PPE, is designed to provide protection from serious injuries or illnesses radiological, physical, electrical, mechanical, or other hazards resulting from contact with chemicals. Considering this Protective need in work environment the present study was conducted. The objective is to study the effect of finishes on the micro polyester fabric. The fabric with good comfort property using various weave structures and finishes treatments so that it can block penetration and permeation of abrasive sulphuric acid and sodium hydroxide used in chemical industry.*

Keywords: *Chemical resistant, Fluorocarbon Finishing, micro polyester, Protective work wear*

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1. Introduction

The term "finishing" in textile manufacturing refers to a set of procedures that transform woven or knitted cloth into a finished material. This process includes any actions that take place after dyeing the fabric or yarn with the purpose of enhancing the appearance, quality, or texture of the finished product, whether it be textile or clothing [2, 3].

The application of fluorocarbon finishes on textiles results in the formation of a consistent polymer film from the dispersion. The water and oil repellency of polyester/cotton blend is observed to be superior to that of cotton. The protective clothing should possess excellent water, oil, and pesticide repellency [4, 5, 6]. Fluorocarbons contain perfluoroalkyl residue in which hydrogen atoms are exchanged by fluorine. They have very high thermal stability. Nano finishes being developed for textile substrates are in their nascent stage. Some of the finishes have been commercialised. These finishes impart additional functions to the material. The commercially available variants are Nano Care TM, Lotus Effect TM, NanosphereTM and Ag Fresh.3 [7, 8].

Replacement of fluorocarbons in the field of repellents of liquids, mainly in waterproof and oleo phobic textile materials, became the crucial issue in attempts to find eco-friendly and efficient barrier systems ensuring both high protective effects and physiological parameters (wearing comfort). Except the hydro- and oleo phobic effects, multi-barrier properties (protection against heat and flame, heat stress and heat stroke protection, soil-release) and relevant physiological parameters (breathability, thermo regulating/insulating properties) and wearing comfort without the movement restriction are required for protective clothing. These properties achieved by customized yarn and fabric construction in combination with textile fiber selection, followed by special textile finishing and garment design (cut, multi-layered structures) [9, 10]. They must comply with cost effectiveness and prolonged service life under the harsh conditions of use and maintenance cycles. Innovative approaches are demonstrated in examples of commercial solutions [11, 12].

The performance of hybrid laminated composites was evaluated for their potential use in protective clothing. Nine types of woven fabrics were utilized, woven with polyester fibers as the warp yarns and three types of weft materials. Three types of weaving structures were employed, with 10 ends/cm and 15 picks/cm. A nonwoven glass fiber mat was selected for use due to its superior performance and cost-effectiveness in the realm of fiber-reinforced composites. It was discovered that the HLC (hybrid laminated composite) fabricated from (polyester/glass) fabric, combined with satin and nonwoven glass fiber mat, displayed the best functional performance. The reinforcement material, structure, and resin properties all played a significant role in the thickness, puncture resistance, and UV transmittance of the produced HLC. The fiber/matrix interface was a crucial factor in influencing the interlaminar fracture toughness of the laminated composites. The HLC fabricated from (polyester/glass) fabrics with satin and glass fiber mat was the most effective in achieving functional performance. This multifunctional HLC was recommended for use in protective clothing as a headwear due to its high puncture resistance and improvement in UV transmittance, as well as its low weight and thickness, which provided comfort [13, 14].

2. Materials and Methods

There is a need of Chemical protective clothing, so the micro polyester yarn was used to develop fabrics. The effect of Finishes was studied on the 6 samples developed in two weaves with 60, 72 and 84 PPI. The fabrics were developed on a power loom in two weave structures i.e., plain and rip stop. Then the samples were finished with two types of finishes Alkyl Urethane (F1) and Fluorocarbon (F2) procured from two manufacturers. These finishes were used to impart oil and water resistance. The recipe used was as prescribed by manufacturer. These finishes were applied with pad-dry-cure method as represented in Plate No. The finish pick up with 20% was given to each sample. All the samples were tested for chemical resistance as per specification of ISO6530.

Plate No.1: Padding Machine **Plate 2: Fabric Ready for Padding**

Table 2: Coding for Finishing

Type of Finish	Code	Chemical Name
Finish 1	F1	Alkyl Urethane (Huntsman)
Finish 2	F2	Fluorocarbon (Resil)
Before Finish	BF	-

3. Results and Discussions

3.1 Effect of Finishes on Comfort Properties

3.1.1 Air Permeability

It was observed that application of Finish 1 lead to increased Air Permeability in some cases. It was also observed that when comparing Plain and Rip Stop weaves, Rip Stop weave with 60 picks allowed more Air Permeability than Plain Weave as shown in Table 3 and Figure 1. The below graph is shows that as the pick increases the Air Permeability decreases. In filament fineness 0.53 dtex, the fabric with 60 picks has Air Permeability of 6.7 $cm^3/cm^2/s$ is before finish but after the application of Finish1 it increased to 9.1$cm^3/cm^2/s$. Thus, the finishing treatment has resulted in increase of Air Permeability.

Table 3: Effect of Finishes on Air Permeability

Filament Fineness	Weave	Ends	Picks	GSM	Air Permeability Before Finish	Air Permeability Finish F1	Air Permeability Finish F2
0.53	Ripstop	102	62	148	6.69	9.1	8.00
0.53	Ripstop	104	78	151.25	2.495	1.2	1.20
0.53	Ripstop	104	86	160.4	1.5	0.8	0.51
0.53	Plain	104	62	146.9	4.357	3.51	2.93
0.53	Plain	102	74	152.7	2.368	1.202	0.92
0.53	Plain	96	86	154.95	0.55	0.631	0.58

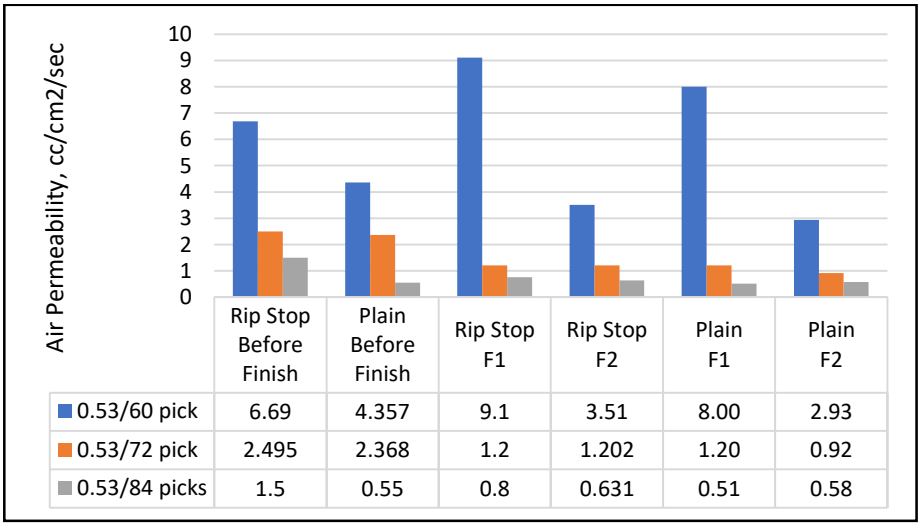

Figure 1: Air Permeability Before and After Finish

3.1.2 Water Permeability

It was observed that water vapor transmission has decreased with the application of finishes. As represented in Table 4 and Figure 2. It was observed that in Micro Yarn with PPI 60 in Plain weave water permeability increases when finish 1 and finish 2 is applied, whereas with PPI 72 and 84 the Water Permeability decreases

when finish is applied. Thus, the finishing treatment has resulted in increase of water permeability only with lower PPI. The purpose of water permeable fabric is to make it comfortable to the wearer [15].

Filament Fineness	Weave	Ends	Picks	GSM	Water Permeability Before Finish	Water Permeability Finish F1	Water Permeability Finish F2
0.53	Ripstop	102	62	148	9.83	6.5	9.76
0.53	Ripstop	104	78	151.25	8.4	5.4	8.19
0.53	Ripstop	104	86	160.4	8.34	6.13	7.9
0.53	Plain	104	62	146.9	5.68	7.75	8.48
0.53	Plain	102	74	152.7	9.04	6.06	6.83
0.53	Plain	96	86	154.95	8.42	8.3	6.68

Table 4: Effect of Finishes on Water Permeability

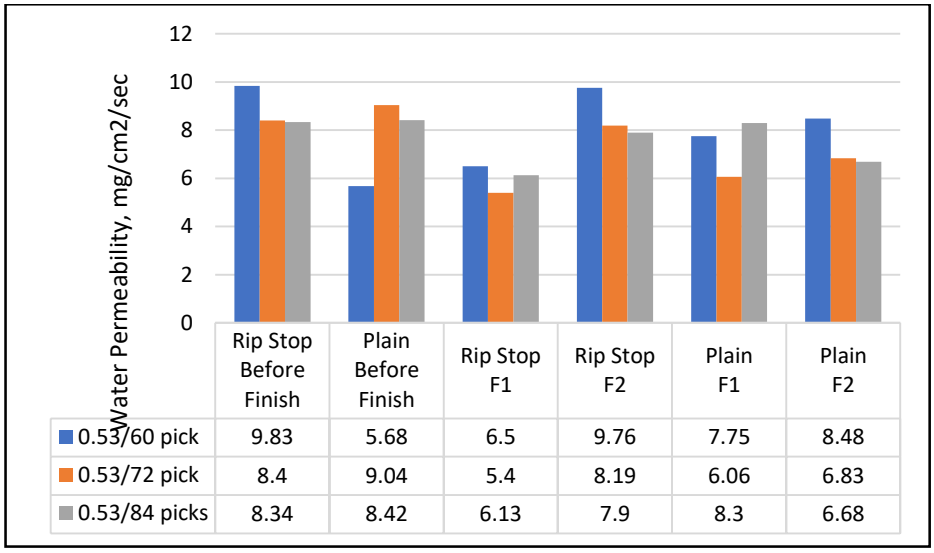

Figure 2: Water Permeability Before and After Finish

4. Effect of Finishes on Durability

4.1 Tensile Strength

As represented in Table 5, the Micro Yarn in Ripstop weave with 84 picks has the maximum Tensile Strength. Figure 3 shows that after the application of Finish 2 the Tensile Strength increased in Plain Weave. The results showed in Table 5 and Figure 3 that application of finish lead to increase in Tensile Strength. Thus, the Finish 2 resulted in increasing the tensile strength of fabrics woven with micro yarn.

Table 5: Effect of Finishes on Tensile Strength

Filament Fineness	Weave	Ends	Picks	GSM	Tensile Strength Warp and Weft (Before Finish)		Tensile Strength Warp and Weft (F1)		Tensile Strength Warp and Weft (F2)	
0.53	Ripstop	98	64	142.7	1148.5	779.1	1175.5	701.9	1238	698
0.53	Ripstop	102	78	152.65	1127	873.4	1176	979.25	1205.5	927.4
0.53	Ripstop	100	90	156.2	1131.5	1058	1229.5	1047	1230	1107.5
0.53	Plain	104	62	146.9	1144.5	822.25	1107	800.55	1068.5	803.3
0.53	Plain	102	74	152.7	1160.5	918.1	1150	876.3	1150	900.3
0.53	Plain	96	86	154.95	1057.5	971.1	1132	1064	1120.5	1058.5

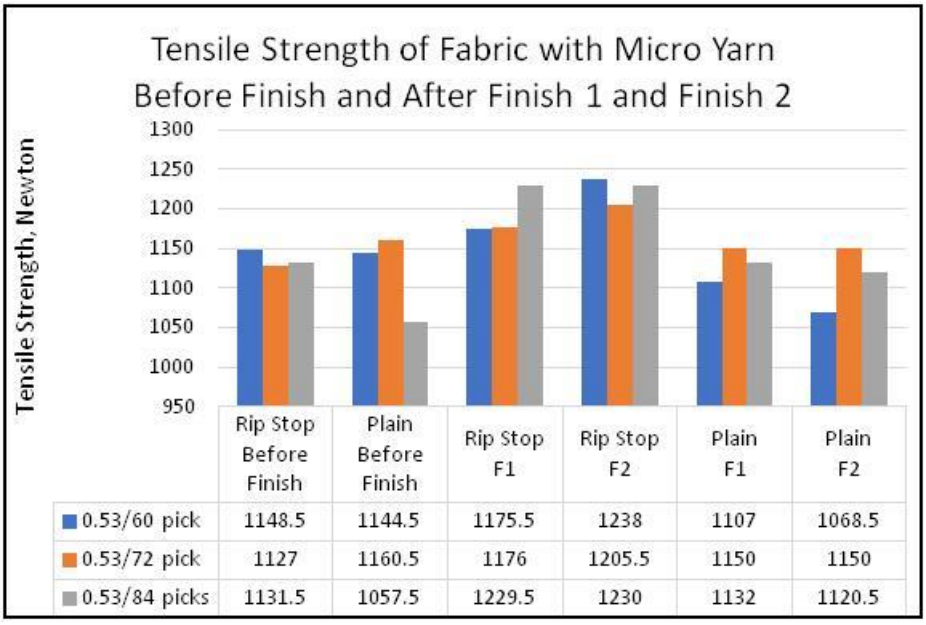

Figure 3: Tensile Strength before and after finish

4.2 Tearing Strength

It was observed that the Tearing Strength increased after the application of finish. Application of Finish1 resulted in higher increase in Tearing Strength of both warp and weft yarns as compared to Finish 2. Table 6 represents the warp and weft Tearing Strength. It can be observed from Figure 4 that Tearing Strength increased with Finish 1 in all the Picks. Also, the 60 picks showed more Tearing Strength as compared to others. The GSM also increased with the increase in pick. It was observed that the 60 picks with filament fineness 0.53 in Ripstop weave have the maximum Tearing Strength. The ISO recommends tearing strength as 15 N for the protective clothing.

Table 6: Effect of Finishes on Tearing Strength

Filament Fineness	Weave	Ends	Picks	GSM	Tearing Strength Warp and weft		Tearing Strength Warp and weft(F1)		Tearing Strength Warp and weft (F2)	
0.53	Ripstop	102	62	148	35.6	27.5	99.3	75.4	80.2	65.9
0.53	Ripstop	104	78	151.25	43	33.7	82.3	69.7	50.7	48.4
0.53	Ripstop	104	86	160.4	31.4	27.8	62.2	51.5	50.7	35.9
0.53	Plain	104	62	146.9	39.8	27.8	57.4	41.9	44.6	33.7
0.53	Plain	102	74	152.7	32.2	25.2	40	32.6	33.9	29.5
0.53	Plain	96	86	154.95	28.4	21.5	38.1	28.1	31.2	25.5

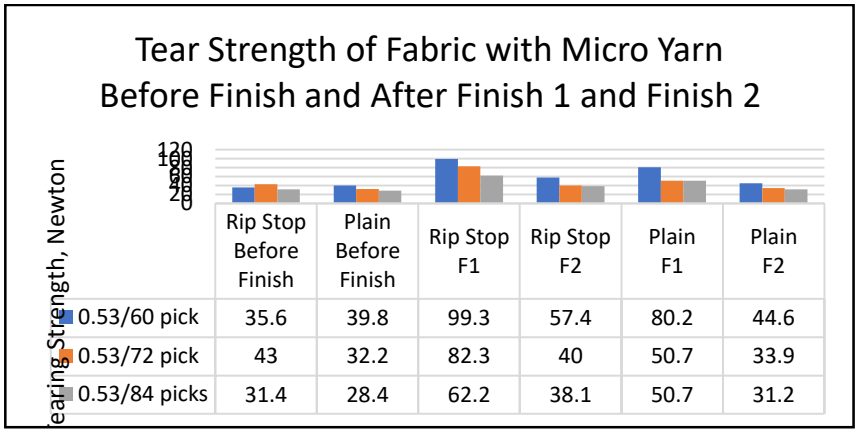

Figure 4: Tearing Strength Before and After Finish

4.3 Effect of Finishes on Chemical Resistance

All fabric samples of micro polyester woven in Ripstop and Plain Weave treated with F1 and F2 finish shows 100% chemical resistance and 0% chemical penetration.

5. Conclusion

All fabric treated with F1 and F2 finish showed 100% chemical resistance and 0% chemical penetration. It was also observed that the air permeability decreased with the increase in picks. It was observed that application of Finish 1 lead to increased air permeability in some cases. It was also observed that when comparing Plain and Rip Stop weaves, Rip Stop weave with 60 picks allowed more air permeability than Plain weave. In filament fineness 0.53 dtex, the fabric with 60 picks showed air permeability of 6.7 cc/cm2/s before finish but after the application of finish 1 it increased to 9.1cc/cm2/sThus, the filament fineness 0.53 dtex and Finish 1 has resulted in increase of air permeability. It was observed that water permeability has decreased with finish application. It was also observed that when Finish F1 was applied then water permeability was not affected thus making F1 finish more apt for the said end use in this study. The comfort and chemical resistance are desired characteristics for the development of this fabric.

Water vapour transmission of micro yarn was best with PPI 72. The results show that application of finish made the samples chemical resistant. Samples woven in 84 picks Micro Yarn showed increase in Tensile Strength with application of finish 2. After the application of finish F1 the tearing Strength increased considerably in samples woven in 60 picks. The results showed that both the finishes resisted the penetration of chemicals tested in Rip Stop Weave. The micro yarn with 84 picks showed the maximum tensile strength. Figure 3 shows that after the application of Finish 2 the tensile strength increased in plain weave. Tearing strength increased with Finish 1 in all the Picks. Also, the 60 picks showed more Tearing Strength as compared to others. The mass in g/m2 increased with the increase in pick. It was observed that the 60 picks with filament fineness 0.53 had the maximum tearing strength of 57.5 N in plain weave. The ISO recommends tearing strength as 15 N for the protective clothing. Here, F1 finish with 60 picks and 0.53 dtex filament fineness had maximum tearing strength. The tearing strength was lowest i.e. 28.4 N in case of filament fineness 0.53 dtex with 84 picks without the application of any finish. The tearing strength increased after the application of finish. Application of Finish 1 resulted in higher increase in tearing strength of both warp and weft yarns as compared to Finish 2. The sample woven in 60 picks with micro yarn and rip stop weave with Finish 1 was best for developing work wear.

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