

Development of Wrinkled Look Faded Effect on Knit Wear through Acid Wash and Investigation on Physical Properties

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ABSTRACT: Garments washing is a frontier area in the field of apparel engineering and contain a great scope for developing new fashion trend. Acid wash on sewn garments is one of the most accepted finishing process which is used to produce irregular fading effects, to improve soft hand feel, also for aesthetic and fashionable look to achieve the buyer standard & expectation. This paper develops wrinkled look faded effect on single jersey 100% cotton knit T-shirt through acid wash (Nylon net bag, Potassium per manganite and Thermocol balls). Typical washing procedures and techniques were followed and analyzed physical properties of wrinkled look faded acid washed knit wear using standard test methods under standard condition. It is found that fabric weight, CPI, WPI increases even though the bursting strength decreases after washing treatment under controlled P^H which is 7. There is no change in pilling, colour fastness to wash, water and dry rubbing while a little bit decrease in wet rubbing with improved soft hand feel. This paper developed acid wash on knit wear (T-shirt) with wrinkled look faded fashion appearance.

Key words: Acid wash, Wrinkled look, faded effect, Nylon net bag, Potassium per manganite, Thermocol ball.

1. INTRODUCTION

Generally garments means a clothing which is worn in the body after sewing of fabric and with all types of trimmings and accessories with it. Which is the second of basic needs of human being side by side it represents the socio-economic class and an individual's identity [1]. As the garments nowadays represents individual tastes, social and economic condition, their culture, side by side believes, therefore the consumers now are more caring about the fashionable colour and effect, in total about Fashion apparel. Apparel which is not only used for functional purpose rather it is used for fashion purpose is termed as fashion apparel. Washing is a technology which is used for cleaning, modifying the appearance, size, colour, outlook, comfort ability, design, fashion etc. [2].

In RMG (Ready Made Garments) industry, washing is considered as the last stage to make finished complete garments [3]. Some types of washing got popularity among the customers all over the world. Due to this reason textile manufacturer are trying to develop new techniques for making the garments more attractive. Bleach wash, Enzymewash, Acid wash, Stone wash, Super white wash, PP spray, Sand blasting, Hand scraping, Overall and

permanent wrinkle etc. are used by manufacturer to achieve consumer washing standard [4]. Young customers are now preferring the faded looked garments around the whole world [3]. In 1980s, acid washed effect on jeans turned into the most fashionable all over the world [5]. During Acid wash, Irregular fading effect is developed on the heavy garments like denim, thick canvas/twill and sweater for the brushing action of pumice stone [6]. But most recently acid wash is being available on Knit garments. Faded effect on Knit wear is done by acid wash with pumice stone or others substitutes [3].

Thermocol balls are used as substitutes in acid wash. Available diameter of thermocol balls are 0.25 cm to 5 cm for producing faded look on garments. Small size thermocol balls are used to create regular faded effect moreover medium and large sized thermocol balls are used to produce irregular faded effect on garments. In washing machine, $\frac{1}{2}$ volume of thermocol balls should be loaded [5]. An inorganic chemical substance as well as a strong oxidizing agent is potassium permanganate ($KMnO_4$) which is applied to produce faded effect on garments [7] [3]. potassium permanganate is also works like a decolouration agent for color out from the garments in acid wash with pumic stone [8].

Sodium metabisulphite is used to neutralize activity of chlorine of fabric/solution [8]. Sodium metabisulphate acts as a De-chlorination agent after acid wash with potassium permanganate ($KMnO_4$) [8] [9]. Improved hand feel that is both silky and soft with excellent lubricating properties softener and silicon is used ((Robin), 2010). Softener act as a "fabric conditioner" to improve softness [10].

M. Z. Hasan et al. (2017) studied on different wash process on indigo dyed four way stretch denim fabric and one was

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Acid wash-Enzymatic treatment with potassium permanganate and pumic stone. Analyzed properties like fabric weight, tear strength, dimensional stability, color fastness to wash, water, rubbing, light, perspiration and ozone and explained clear comparison with each other before and after washing [9].

Elias et al. (2016) investigated on physical properties GSM, CPI, WPI, bursting strength, stitch length, shrinkage, spirality, pilling and color fastness to wash, water, rubbing of Single Jersey 100% Cotton T-shirt, Single Jersey 95% Cotton 5% Spandex T-Shirt and 1 × 1 Rib 100% Cotton T-Shirt after acid wash (with Thermocol balls and KMnO_4). It was analyzed that fabric weight increased while bursting strength and wet rubbing decreased after acid wash at P^H lies between 7 to 8 [3].

Solaiman et al. (2015) executed Enzyme, Softener and Silicone wash on 100% cotton Single Jersey T-shirt, Slub Single Jersey T-shirt, Double Lacoste (5% Lycra) Polo shirt, Single jersey CVC (T-shirt) and PC single Jersey (T-shirt). Then analyzed physico-mechanical properties and found that after wash GSM of each garments has increased from 5% to 36%, unchanged shrinkage % color fastness to wash and stain, spirality, improved dry and wet rubbing properties [11].

However, wrinkled look faded effect on knit wear through acid wash with nylon net bag, potassium permanganate and thermocol balls was not developed in the previous research. In this present study, developed wrinkled look on garments surface by doing hot wash on tightly wrapped T-shirts (100% cotton single jersey) with nylon net bag, acid washed with thermocol balls and analyzed physical properties under standard condition. The aim of this paper is to develop knit wear through acid wash which had a new fashion look (wrinkled look faded effect).

2. RESEARCH METHODOLOGY

2.1 Materials

In this paper, single jersey T-shirts were used. These comprised direct dyed 100% cotton single jersey, 160 GSM with 60 CPI and 44 WPI, bursting strength 214.4 KPa. These sewn garments were collected from Esquire Knit Composite LTD. Wetting agent, Acetic acid (India), Soda ash, Potassium permanganate (KMnO_4), Phosphoric acid (H_3PO_4), Catalyzer, Detergent, Sodium metabisulphite (Hypo, china), Softener, Silicon were used for this experiment. A nylon net bag and thermocol balls (Turkey) were used for soaking Potassium permanganate (KMnO_4).

2.2 Machineries

Sample Washing Machine (Naga-Shing; Model No: XGQ-100F) was used for desizing and dyeing process (Capacity/ 5 kg). Acid Washing Machine (AZIZ METAL ENGINEERING WORKS; Model No: 2300567L) was used for acid washing process (Capacity/ 50 garments). Hydro extractor Machine (CENTARY FATH; Model No: JHG 237B9) was used for hydro extraction process (Capacity/ 50

garments). Dryer Machine (CENTARY FATH; Model No: GDS dryer 300) was used for drying garments (Capacity/ 100 garments).

2.3 Methods

The process of Acid wash with thermal shock on direct dyed garments of 1 kg batch is mentioned below:

2.3.1 Pre-treatment/ Desizing

The desizing was conducted in liquor containing Wetting agent (1 g/l), Acetic acid (0.3 g/l) and material to liquor ratio of 1:20 in the Sample Washing Machine at temperature 60°C for 10 min. After that garments washed with hot water (70°C) followed by cold water (32°C) wash. Then drained out the liquor and rinsed these garments with normal water one times.

2.3.2 Hydro Extraction and Drying:

Direct dyed T-shirts were squeezed in a Hydro extractor machine at 200 rpm for 3-4 min. and dried at temperature 107°C for 20-25 min in a Dryer Machine (Model No: GDS dryer 300).

2.3.3 Wrinkled Look Effect through Hot Wash

In sample washing machine rinsed T-shirts with normal water are kept at 30°C for 5 min. in containing material to liquor ratio 1:25. Then excessive water is removed through a Hydro extractor machine at 200 rpm for 3-4 min. Wetted Garments were tightly tied with nylon net bag in double layer compactly then hot wash was done at 92°C for 5 min. in a sample washing machine at 50 rpm. After hot wash produced a temporary wrinkled look effect on garments surface. After that rinsed these garments one time with normal water (30°C). Excessive water was removed by a Hydro extractor machine at 200 rpm for 3-4 min.



Figure 1: Sample washing machine

2.3.4 Acid Wash

Thermocol balls (½ volume of machine) were presoaked with a chemical mixture of potassium permanganate (KMnO_4) 50 g/l, phosphoric acid H_3PO_3 (5%), catalyzer (50 g/l) and 1 liter water for 10-15 min in an Acid Washing Machine (AZIZ METAL ENGINEERING WORKS; Model No/ 2300567L). Then soaked thermocol balls were dried in the open air for 10 min. Pretreated garments were loaded into the machine and run for 2 min.



Figure 2: Acid washing machine

2.3.5 Hydro Extraction and Normal Wash:

Acid washed T-shirts were squeezed for removing excessive water through a Hydro extractor machine at 200 rpm for 3-4 min. and dried at temperature 107 °c for 20-25 min in a Dryer Machine (Model No: GDS dryer 300). Then normal wash is done with detergent (1 g/l) for cleaning at 30°C.



Figure 3: Hydro extractor machine

2.3.6 Neutralisation

Finally Neutralization was done by Sodium Metabisulphite 5 gm/l (125 gm) with material to liquor ratio of 1:25 at 40°C. Neutralization was done in Sample Washing Machine at 50 rpm for 5 min.

2.3.7 Hydro Extraction

After Neutralization T-shirts were squeezed in a Hydro extractor machine at 200 rpm for 3-4 min. and dried at temperature 107°C for 20-25 min in a Dryer Machine (Model No: GDS dryer 300).

2.3.8 Soft Wash

Soft washing was comprised with acetic acid (0.4 g/l), softener (15 g/l) and silicon (12 gm/l) at 32°C for 5 min by maintaining P^H 5.5.

2.3.9 Hydro Extraction and Drying

Direct dyed T-shirts were squeezed in a Hydro extractor machine at 200 rpm for 3-4 min. and dried at temperature 107°C for 20-25 min in a Dryer Machine (Model No: GDS dryer 300).

2.3.10 Process Flow

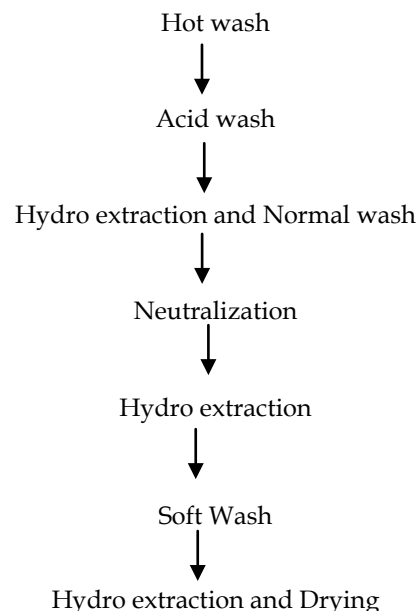
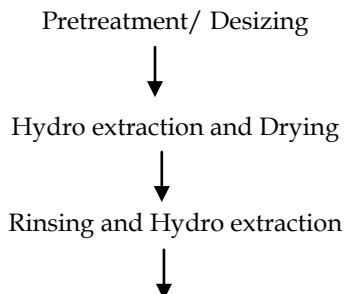


Figure 4: Process flow of Acid wash on Direct dyed T-shirts for Wrinkled look effect

3. TESTING AND ANALYSIS

All acid washed direct dyed T-shirts were tested according to BS EN 20139 and ASTM D1776 after conditioning at 20°C and 65% RH (Relative Humidity) for 24 hours. According to ASTM D3776- 96 (Reapproved 2002), Fabric Weight in GSM was calculated in case of after and before treatment [12]. Color fastness to washing and water were determined respectively according to ISO 105-C10:2006(E) and ISO 105-E01:1994(E) [13][14]. Color fastness to rubbing samples were evaluated by crock meter ASTM D 3776(1996) [15]. CPI and WPI of the fabric was calculated by counting the number of the Coarse and Wales contents in 1 inch of the fabric. IS 1963 method was used for this measurement [16]. An automatic bursting strength tester (James Heal bursting strength tester machine) is used for measuring bursting strength according to ASTM D3786- 01 [17]. According to ISO 6330, after 1 wash staining and color change is assessed [18]. According to ISO 12945-1:2000(E) ,pilling resistance and fuzzing is measured after washed T-shirts [19]. Shrinkage % is measured under ISO 5077:2007(E) [20]. Spiralty is measured by using ISO 16322-1:2005(E) [21]. ISO 3071:2005(E) method was used for measuring P^H of the fabric [22].

4. RESULT AND DISCUSSION

4.1 Effect of Acid Wash on HandFeel of Knit Wear(T-Shirt)

The hand feeling of the garments have enhanced totally after acid wash treatment .This improved soft hand feel has been found in each successive stages of processing. After desizing process a soft hand feel has developed even after acid washing a more soft hand feel also found on garments

Softening process added a prominent soft and silky hand feel.

4.2 Effect of Acid Wash on Physical Properties of Knit Wear (T-Shirt)

The effect of physical properties before and after acid wash which includes pre-treatment, hot wash, acid washing, and neutralization treatment has been analyzed. The specimen was went through several test to understand the different effects caused by the washing treatment some of the test results are mentioned below-

4.2.1 Effect on Fabric Weight

All T-shirts have been conditioned in standard atmosphere 20°C±1 and 65%±2 RH. After conditioning fabric GSM was counted both in before and after washing treatment according to ASTM D 3776. Where it is found that there has been an increase in case of GSM every time. The GSM readings was averaged and the average GSM before wash was 160 while at after wash it increased to 162 around 1.23% increased.

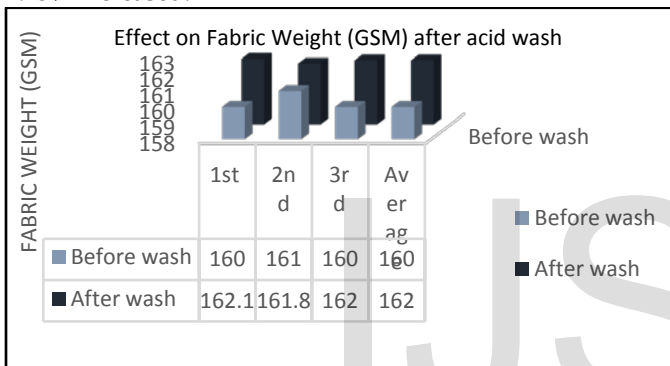


Figure 5: Effect on fabric weight (GSM) after acid wash

4.2.2 Effect on Bursting Strength

After conditioning T-shirts under Standard testing condition (20°C±1 and 65%±2 RH) took three sample of 125mm diameter square sample inserted under tripod and clamp specimen in place by bringing the clamping lever. Rotate the hand wheel at 120 rpm clockwise in a uniform speed until the specimen bursts. When rupture occurred stop the hand wheel and recorded the bursting strength. From the specimen bursting strength was also analysed and the average bursting strength found before

wash was 213.43KPa while after the treatment done, the average bursting strength found was 198.9KPa. Here the friction of the cylinder of acid washing chamber, Specimen and the thermocol balls played a huge role decreasing the strength of the fabric and side by side the KMnO₄ solution also reduced the strength parameter of the specimen which altogether resulted into the decrease of the bursting strength.

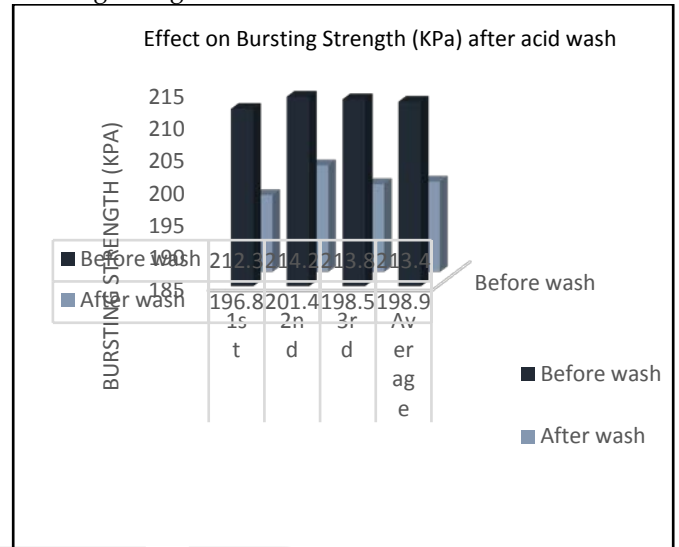


Figure 6: Effect on bursting strength (KPa) after acid wash

4.2.3 Effect on CPI and WPI

For measuring CPI and WPI, 1 inch sample took from the garments (T-Shirt) and marked with ball pen according to the courses and wales of the knitted garments(T-shirts). Then counted CPI and WPI in 1 inch after setting the marking point with multiplier scale. Magnifying counting glass is used for counting for CPI and WPI. Here CPI and WPI properties from the specimen before wash and after wash was also analysed where at before wash treatment, the average CPI found was 60 and average WPI found was 44 but after wash treatment done, due to the frictions and the actions of KMnO₄ and H₃PO₄ solution the internal structure of molecules of fibres got affected resulting into the contraction of yarns, therefore the stitch density also increased. Therefore the CPI increased to 62 and WPI increased to 46 on an average.

Table 1: Effect on CPI and WPI changes after acid wash

No. of observation	CPI and WPI			
	Before wash		After wash	
	CPI	WPI	CPI	WPI
1	60	43	62	46
2	61	44	62	46
3	60	44	61	45
Average	60	44	62	46

4.2.4 Effect on pilling resistance and fuzzing

Before pilling test conditioning is done on 125mm×125mm cut under (20±2)°C and (65±2) % RH for at least 16 hour. Prepare mounting specimen and placed specimen in pilling testing box. Close and firmly secured the lid. Tumble the tube with specimen in the box for 125 cycles, 500 cycles and 100 cycles. Remove the specimen from the box and unstitch the seam. According to ISO 12945-1:2000(E), pilling and fuzzing is assessed with reference the before washed original sample under illuminant 065 by using

Visualization grade. Observation has found that no strong influence is done on pilling and fuzzing properties after acid wash.

Table 2: Effect on pilling and Fuzzing after acid wash

observation	No. of	Grade
After 125 cycles		4-5
After 500 cycles		4-5
After 1000 cycles		4-5
Average		4-5

Interpretation:

Grade 5- No pilling or fuzzing observed

Grade 4- Slight fuzzing or pilling on the surface

Grade 3- Moderate fuzzing or pilling

Grade 2- Distinct fuzzing or pilling all over fabric surface

Grade 1- Fully formed pilling and fuzzing all over fabric surface

4.2.5 Effect on Colour fastness to water

Prepared test specimens measuring 40mm×100mm sewn along one of the shorter sides with an adjacent multifiber (40mm×100mm). Then wet out all specimens in an immersing water container at room temperature. Placed under pressure at 12 KPa between two glass plates. After that placed the test specimen on oven at 37^oc±2^oc for 4 hours. Then assessed the color change in the sample specimen with reference the original sample under illuminant 065 by using grey scales. Acid washed process has no strong influence on colour fastness to water. According to ISO 105-E01:1994(E), tested done under standard condition (20±2)^oC and (65±2) % RH. Average color change is 4.5.

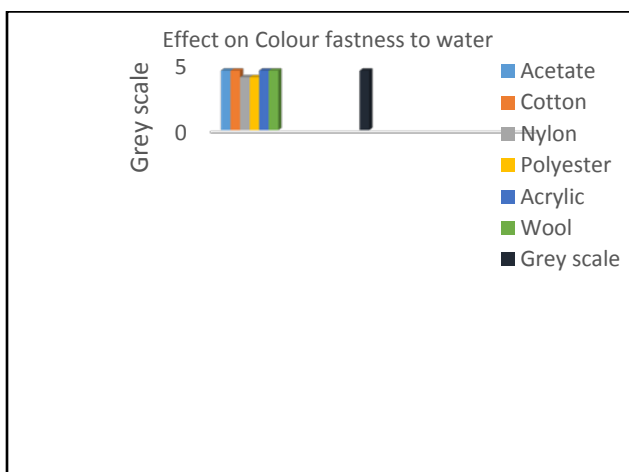


Figure 7: Effect on color fastness to water after acid wash

4.2.6 Effect on Colour fastness to washing

Acid washed process has no strong influence on colour fastness to washing. According to ISO 105-C10:2006(E), Prepared test specimens measuring 40mm×100mm sewn along one of the shorter sides with an adjacent multifiber (40mm×100mm). Prepared soap solution containing 5 g of soap and 2 g of sodium carbonate in grade 3 water (ISO 3696) per litre at (25±2)^oC and stir for (10 ± 1) min. Placed the specimen in stainless steel container with 10 steel ball and soap solution in liquor ratio 50:1 ml/g at 95^oC for 30 minute. After rinsing dried the specimen in air at a temperature less than 60 ^oC, Then assessed the color change in the sample specimen with reference the original sample under illuminant 065 by using grey scales.

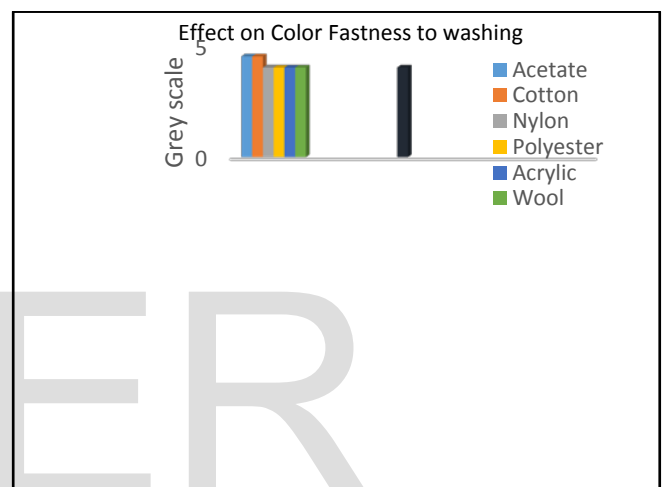


Figure 8: Effect on color fastness to washing after acid wash

4.2.7 Effect on Colour fastness to Rubbing

Acid washed process has no strong influence on colour fastness to rubbing both dry and wet condition. According to ISO 105-X12, six samples of 50mm x140mm(three for dry rubbing and three for wet rubbing)and before testing conditioning is done on six specimens at least 4 hour at (20±2)^oC and (65±2)% RH. Placed the conditioned rubbing cloth, flat over the end of the finger of Crock block . At a rate of one cycle per second, Rub to and fro in a straight line 20 times, 10 times to and 10 times fro, along (104±3)mm a track long on the dry specimen, with downward force of (9±2)N. Same procedure is applicable in case of wet rubbing specimen must be soaked with distilled water at (65±2) % . After air drying, assessed the color change to the specimen with reference the original unwashed sample under illuminant 065 by using grey scales.

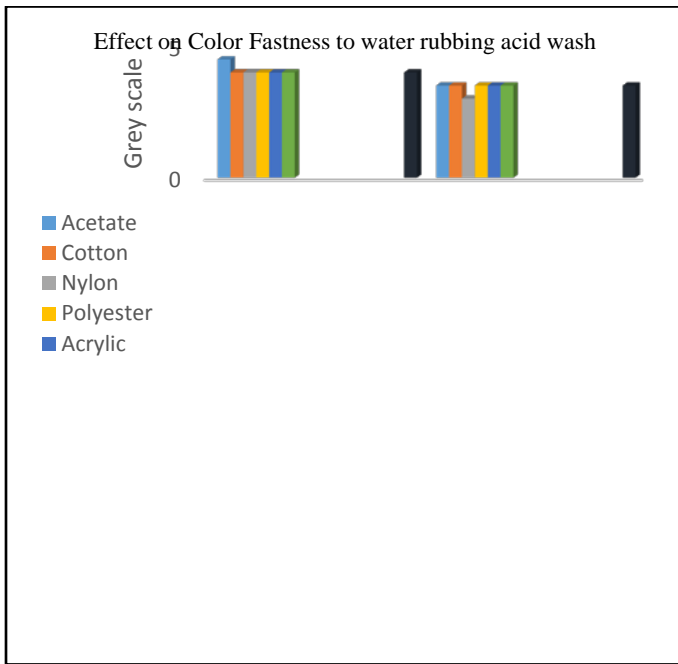


Figure 9: Effect on color fastness to rubbing after acid wash

4.2.8 Effect on Dimensional changes due to Shrinkage %

After acid wash treatment, due to the frictions and the actions of $KMnO_4$ and H_3PO_4 solution the internal structure of molecules of fibres got affected resulting into the contraction of yarns, therefore the stitch density also increased. For this reason shrinkage % found. Atmospheric condition was imposed at $(20 \pm 2)^\circ C$ and $(65 \pm 2)\% RH$. At first specimen is conditioned at $(20 \pm 2)^\circ C$ and $(65 \pm 2)\% RH$ for 4 hours and measured before acid wash. After acid washing, conditioned and measured the specimens and calculated the dimensional change of the specimens according to the procedure specified in ISO 3759. Calculate the dimensional changes with this equation-

$$\text{Dimensional change} = \frac{x_t - x_o}{x_o} \times 100$$

Here, x_t = dimension after treatment

x_o = original dimension

A plus sign (+) means dimension has decreased (shrinkage)

A minus sign (-) means dimension has increased

Table 3: Effect on dimensional changes due to shrinkage % after acid wash

	Before wash	After wash	Shrinkage %
Body measurements	length (cm)	length (cm)	$-\left(\frac{x_t - x_o}{x_o} \times 100\right)$
Front body length	51.3	50.2	-2.1
Chest	43.2	42.7	-1.2
Bottom	45.1	42.7	-1.3
Centre back length	48.9	44.5	-2.2

4.2.9 Effect on P^H

The P^H-value of an aqueous extract of a textile is measured electrometrically at room temperature by means of a glass electrode (which is calibrated P^H meter). P^H test is done on a sample of 2 gm cut into pieces about 5 mm. Socked into 100ml distilled water and gently shaken in a mechanical shaker in a beaker about 2 hours (± 5) min and took record using a calibrated PH meter. It has found that its almost neutral P^H because in acid wash neutralization is done with sodium metabisulphite. No significant effect on P^H is occurred after acid wash. Average P^H is 7.43

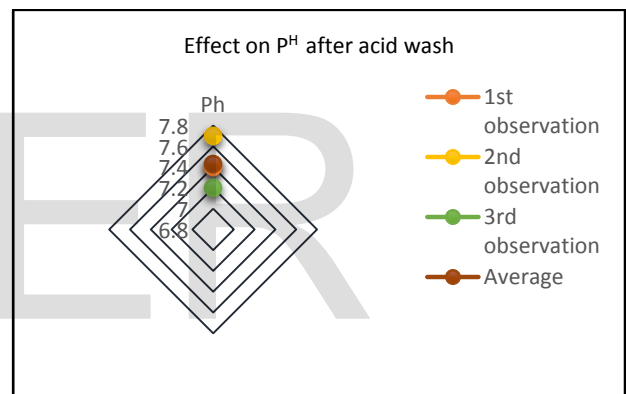


Figure 10: Effect on P^H after acid wash

4.2.10 Effect on Spirality%

A T-shirt was test specimen and conditioned on standard atmosphere at $(20 \pm 2)^\circ C$ and $(65 \pm 2)\% RH$ for 4 hours at least. Wale spirality is common for knit gaments. After acid wash, due to the frictions and the actions of $KMnO_4$ and H_3PO_4 solution the internal structure of molecules of fibres got affected resulting into the contraction of yarns, therefore the stitch density also increased. wales showed a spiral deflection length from seam line. Garments chest measurement was 43.2 cm before acid wash and after wash measured the deflection from right side and left side both. Then measured spirality % using these below equation-

$$\text{Spirality } (\%) = \frac{\text{Averaged deflection length from seamline}}{\text{Fabric length}} \times 100$$

$$= \frac{\text{Deflection length from right side} + \text{Deflection length from left side}}{2} \text{ cm}$$

No of observation	Deflection length from right side (cm)	Deflection length from right side (cm)
1	1.4	0
2	1.5	0
3	1.2	0
Average	1.4	0

Table 4: Effect on spirality % after acid wash

$$\text{Averagedeflectionlength} = \frac{1.4 + 0}{2} \text{cm} = 0.7 \text{ cm}$$

$$\text{Spirality}(\%) = 0.7/43.2 \times 100 = 1.6\%$$

4.2.11 Effect on appearance change after 1 Domestic washing and drying

Appearance changes after (in house test method), we used wash procedure: ISO6330 and Machine used: Wascator, Detergent used: ECEA Det. Test conducted 1 time wash, at 40°C, Screen dry. Color change: 4-5 and Staining: 4-5

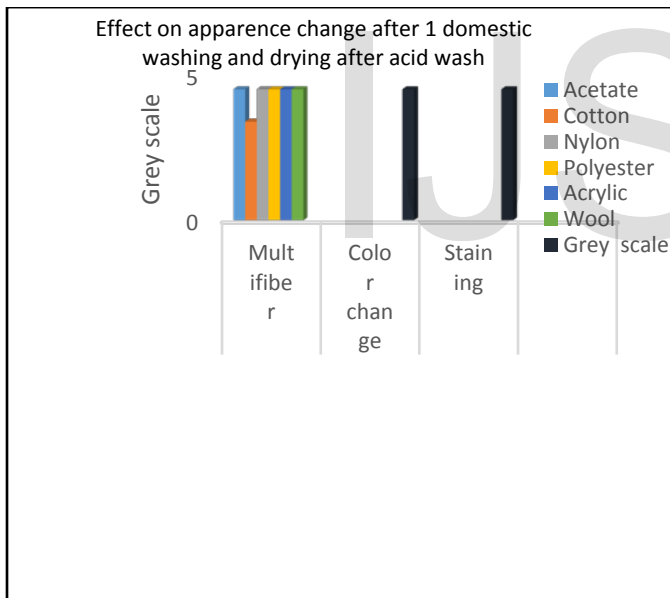


Figure 11: Effect on appearance changes after 1 domestic washing and drying after acid wash

Here presented before and after acid washed Sample-



Figure 12: Before wash sample Figure 13: After wash sample

5. CONCLUSIONS

Acid washing treatment with thermocol balls on direct dyed garments in nylon net bag has developed wrinkled look faded effect and also has a greater effect on the physical properties of knit garments. In this studies it was investigated that the weight of the garments increased but the bursting strength decreased after acid wash .The color fastness properties were good in case of fastness to water and color fastness to wash but the value degraded in case of color fastness to rubbing. A good P^H was maintained throughout the whole procedure. There no strong influence found of acid wash on pilling and fuzzing properties but due to the friction and KMnO₄ actions the body measurements decreased, that is, a percentage of shrinkage was observed side by side it developed a percentage of spirality in the construction of fabric which was ensured after spirality test. The faded effect could be changed with the increase or decrease of the KMnO₄ solution, therefore an optimum amount is to be chosen considering the required fading effect without hampering the physical properties of the knit wear.

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