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Research Article

Effective Mechanical and Chemical Washing Process in Garment Industries

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Abstract

Garment washing is a significant part of garment industries and it is mainly applied on denim garments and any other casual garments. In the primary stage garment does not inherit customer's desired properties but after washing it become most widely used due to its new appearance, softness, comfort, strength and low cost, which create customer's absolute satisfaction. Garment washing process is provided with a lucrative and glassy outlook by chemical or wet washing process and mechanical or dry washing process. The most widely used dry washing processes for garment are scraping, spraying, whiskering, damages, spots, rubbing and tacking contrariwise wet washing processes for garment to develop new a look and effect are normal wash or rinse wash, pigment wash, caustic wash, silicon wash, enzyme wash, stone wash, stone enzyme wash, bleach wash and acid wash. This study gives an indication different types washing process and the change of physical and chemical properties due to application of wet and dry washing processes as an imparting desired effect on garments.

Keywords: Garments; Wet and Dry Washing; Mechanical; Chemical

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Introduction

Washing is the technology which is used to modify the appearance, size, outlook, comfort ability and fashion of the garments is called garment washing [1]. It is mainly applied on denim goods and any other garments. In washing process, a garment is provided with a lucrative economical and glassy appearance [2]. Washing operations carried out most frequently during a complete textile finishing cycle. They are almost always connected to key treatments and aimed at removing from the fabric insoluble matters, matters already in solution or an emulsion of other impurities [3]. To execute the buyer requirement washing is very important process of garment products. For this reason, large number of washing factory is establishing in Bangladesh [4]. Garment is uncomfortable to wear, without washing due to its weaving, dyeing and printing effects. It essentially needs a finishing treatment to make it softer, suppler and smooth which enhance wearer's comfort that's way washing is one of the most widely used finishing treatments due to its effects on appearance and comfort [5, 6].

The wet washing process of garments to create a better look or effects by normal wash or rinse wash, pigment wash, caustic wash, silicon wash, enzyme wash, stone wash, stone enzyme wash, bleach wash and acid wash [7]. In dry washing process, the most important finishing treatment for garments, is done to impart scraping, spraying, whiskering, damages, spots, rubbing and tacking on garments or denim products [8]. Washing process applied a combination of wet or dry process on raw sample to develop certain effect in the garments and measured the change of mechanical or physical properties due to application of different wet or dry washing process. The study is related to the combination of wet or dry washing process on garments or other casual garments. Wet washing process is the most important finishing for garment to improve the outlook which influences the chemical properties of garments on the other hand, dry washing process is the most important finishing for garment which influences the mechanical properties of garments. A number of combinations of dry washing process are carried out on denim to get desired effect. Wet and dry washing process is most widely used to get the chemical and mechanical properties on garments by replacing the conventional process [9, 10].

Machine used in washing plant

- Sample washing machine (Horizontal or vertical)
- Washing machine (Side loading)
- Washing machine (Front loading)
- Hydro extractor machine
- Dryer machine (Steam or gas)
- Chemical mixture machine
- Industrial oven (Gas or electric)
- Boiler
- Submersible pump
- Grinding machine
- Tagging machine
- Steam chamber for crinkle
- Sand blasting Gun
- Sand blasting chamber
- Spray gun and dummy
- Screw compressor
- Laser draw
- Generator

Types of chemical used in washing plant

- Enzyme
- Detergent
- Acetic acid
- Antistain
- Bleaching powder
- Sodium hyposulfite
- Caustic soda
- Soda ash
- Sodium bicarbonate
- Potassium permanganate
- Cationic / Nonionic flax softener
- Micro emulsion silicon
- Salt (sodium chloride)
- Buffer
- Hydrogen peroxide
- Stabilizer
- Fixing agent
- Catanizer
- Optical brightener
- Resin
- Sodium metabisulphite
- Desizing agent

The function of chemicals used in washing plant

Enzyme: The action of enzyme during enzyme wash it hydrolysis the cellulose. At first it attacks the having projecting fibers and hydrolyzed them. Then it attacks the yarn portion inside fabric and party hydrolyzed the yarn portion. As a result, color comes out from the yarn portion and faded affect is produced.

Detergent: Chemical character is fatty alcohol polyglycol ether in an aqueous, glycolic solution. Detergent is widely applicable in the continuous and discontinuous pretreatment of all types of fiber and their blends. To remove impurities, mineral oil contamination and sizes from the garments.

Acetic acid (CH_3COOH): Acetic Acid is used to neutralize the garments from alkaline condition and to control the pH value in wash bath.

Antistain: Antistain is used to prevent the staining on weft yarn of the denim (white yarn), white pockets of garment, levels, and contacted fabrics of garment and increased the brightness of fabrics; it is also acts as anti-creasing agent.

Bleaching powder: Bleaching powder is an oxidizing agent. It is used in washing plant for color out from the denim garments. We can achieve deferent shade of color on garment (Dark, medium, light shade).

Sodium hyposulphite: Sodium hyposulphite is used to neutralize the garments from chlorine bleach.

Caustic soda: Caustic created the role in bleach technique without color change the garment and has a good cleaning power. It is work as fading affect or old looking affect come rapidly on garments.

Soda ash: Soda ash creates alkaline medium for the breakdown of pigment dye. Soda ash help to uniform bleaching action on bleach bath. It has a cleaning power and help color fading effect of garment. It is used also for color fixing in dye bath.

Sodium bicarbonate: Sodium bicarbonate is used in washing plant in the bleach bath with bleaching powder for denim light shade because easily color out with in shot time. As a result, production increase and costing is low.

Potassium permanganate(PP): Potassium permanganate is used in acid wash with pumice stone for color out from the garments. It is used also spray chamber by nozzle for color out (whitish affect) from the garments.

Flax softener (Cationic, Nonionic): Softener is used to make the garments treated textiles a surface feel that is both sickly and soft and also provides excellent lubricating properties. Flax softener (cationic or nonionic) diluted with hot water then use in the machine.

Micro emulsion silicon: Amino Silicon is a textile finishing agent consisting mainly of amino modified silicon. When applied on fabrics, it gives durable softness, lubricity, elastic handle, anti-pilling, dimensional stability, tear resistance and fabric to be cut and sewn more easily allows and improving wear and easy care properties.

Sodium chloride (salt): It helps to exhaust dye in to the fiber.

Buffer: Buffer is used in washing plant for pH control of enzyme bath, softener bath, desizing bath.

Hydrogen peroxide: Hydrogen peroxide creates the prime role in bleach wash technique. In alkaline medium, hydrogen peroxide breaks up and gives some perhydroxhyl ion, which discolor the coloring materials and as a result fading affect is developed. Hydrogen peroxide is used in scouring, bleaching bath for white or ready for dyeing of gray fabric garments. It is used also neutralized the garment from alkaline condition.

Stabilizer: Hydrogen peroxide is work a good condition at temperature above 90 ℃, when temperature raise to 90 ℃ then break the hydrogen peroxide. Stabilizer is used to protect break the hydrogen peroxide and peroxide works in bath smoothly.

Fixing agent: Fixing agent is used for unfixed dye to fix on fabrics, when fabric color will be proper fixing then color fastness and rubbing fastness will be increased.

Catanizer: Catanizer is used in pigment exhaust method processing. Pigment is color not dyestuff. Pigment colors have no affinity to fabric when catanizer is used in fabric then increase the affinity between pigment color and fabrics.

Optical brightness: Two types of optical brightener are used in the washing plant, red brightener and blue

brightener. Mainly optical brightener is used for improve the brightness of garments.

Resin: Resin is high efficiency textile resin based on etherified dimethylol glyoxalin monoureine urea. Resin is used for the creation of semi-permanent creases in denim and other cellulose fabrics. It is used also cotton and polyester fabric. Fabric retains soft handle after washing.

Sodium metabisulphite: Sodium metabisulphite is used in the washing plant to neutralize the garment from potassium permanganate.

Desizing agent: Desizing agent is used to remove mainly starches, cmc, waxes, fats pectin's, minerals and unfixed indigo dye from denim, twills, poplin and canvas fabrics.

Objects of washing:

- To remove sizing materials and to soften the garment.
- To remove dirt, dust and waste materials from garments.
- To remove harmful materials from garments.
- To increase brightness of garments.
- To modify the appearance to make fashion.
- To create different effects and finishes.
- To create vintage look and used effect.
- To make directly wearable after purchase.
- For garments wash shrinkage occurs, so accurate measurement can be found by customers.
- Fading effect is varied here by variation of amount of detergent used, processing time and processing temperature.

Types of washing: Mainly there are two types of washing, such as:

- Dry or mechanical process
- Wet or chemical process

Dry process or Mechanical washing process:

In garments washing, there are some processes which have done without using any chemical or without using any garments loading washing machine are called dry process or mechanical process. Sometimes dry process can be done by using mechanical method [11, 12].

Types of dry washing processes applied in garments:

- Scraping
- Spraying
- Whiskering
- Damages
- Spots
- Rubbing
- Tacking

Scraping

Scraping is a process to remove color from the surface of denim fabric to create worn out effect on the garments. This effect is done by different methods but it is very difficult to get even look as per buyer requirements, so experienced operator should do this process. Figure 1 indicates scraping washing effects.

Objects

- This process is done before wet washing of the garment.
- It is done on garments to get distress look.

- Fabric is scrapped with different tools in order to get a used effect.
- All scraping processes are done manually, so it is difficult to achieve consistent finishes every time.

Types

I. **Sand blasting:** In sand blasting process aluminum oxide are suitable for denim which is use as abrasive tools. Compressed air guns shoot sand forcibly onto desired area of denim fabric to create abrasion.

II. **Hand sand:** Abrasion of the fabric surface is done with sand paper. This process is done by hand. It can work at very high pressure, which is a major requirement for high production.

III. **Hand sand all over:** The most important factor is to select right number of paper according to the fabric strength and intensity need. Scraping is done all over the garment by sandpaper.

IV. **Laser scraping:** Laser machine is used to get the effect. This process is very expensive.

V. **Central crease mark:** Jeans is folded and then scraping is done by ironing with temperature and pressure or by sand paper.

VI. **Crimping:** Fabric is crimped then ironed with high temperature and pressure to create crease marks.

VII. **Pocket mark:** scraping is done to make the inside pocket visible

VIII. **Side seam hand sand:** Hand sand is applied on the side seam of the garment.

Figure 1 Scraping effects on denim

Spraying

In this process chemical is sprayed onto jeans by a spray gun. The main purpose of this process is discoloration as shown in Figure 2.

Objects

- Spraying is done on jeans to take a bright effect.
- Vintage and muddy appearance on denim fabric surface.
- To fix the color and permanent effect on the jeans.

Types:

I. **Spray PP (Potassium permanganate):** PP Spray is being done to achieve local abraded area to appear whiter than back ground indigo color shade on the fabric. PP sprayed onto desired surface of jeans and

PP oxidizes indigo color. This can be done before or after wet washing. There are two steps involved in this process.

Step 1: PP is sprayed onto jeans and dried then pink color appears.

Step 2: Neutralization is done after spraying to get final effect. Normally sodium meta bisulphate is used as neutralizer.

II. **Bleach Spray:** Bleach solution is sprayed or rubbed onto desired areas of jeans. Neutralization is done immediately after spraying. It provides more yellowish tone than PP spray.

III. **Pigment color spray:** Pigment color is sprayed on the upper parts to get a vintage and muddy look. Jeans must be cured in order to fix the pigment and to have permanent effect on jeans.

IV. **Resin color spray:** A mixed solution of resin and pigment color is sprayed onto the garment. It provides unique color and touch that dyeing cannot give.

V. **Resin dip:** Full garment is dipped into a resin solution to produce coating effect on garment.

VI. **Resin color dip:** Full garment is dipped into a resin solution mixed with pigment color. The aim of resin color dip is to produce coating effect and unique color on garment.

Figure 2 Spraying effects on denim

Whiskers

These worn out lines or effects generated by different methods are done mainly on hip and thigh areas of jeans. Mustaches or whiskers are one of the most important design on garment surface. This is also known as cat's whiskers or moustaches which effects is given in Figure 3.

Objects

- This process is famous for its high quality.
- It is also cost-effective.
- it is most frequently used in small industries especially where the production is not consistent to style.
- To get a permanent effect high temperature is required.

Types:

I. **Whiskers:** This is called normal whiskers. Effect is achieved with sand paper or sand blasting.

Process: This is done mainly with the help of sharp edge emery paper rolled on fine wood stick or

pasted on plastic material. Before starting execution placements and pattern must be marked on garments. Stencils can also be used for design.

II. **PP spray whiskers or pigment spray whiskers:** Effect is achieved by spraying potassium permanganate or pigment color. Usually done on top of sand paper whiskers (normal whiskers) to highlight them. Shape or design can be achieved by placing a stencil on jeans.

III. **Whiskers creases:** Fabric is folded in many places and then scrapped on the surface.

IV. **3D Resin whiskers:** Resin is added after normal or PP spray whiskers to make the effect permanent.
Process: Resin is sprayed all over or on local area of the garment with a spray gun. Then whiskers are designed by folding the fabric. To get a permanent effect, garment must be put into oven and dry at high temperature for 30 minutes.

Figure 3 Whiskers effects on denim

Damages

Damage or destruction is an art which make denim look unique and used. In order to achieve favorite vintage look, many damaging processes is necessary. Damages washing effect is shown in Figure 4.

Objects

- The main purpose is get different by distressing.
- This mainly done warp wise to make white yarn visible.
- It is done mainly on pocket edges and hem.

Types:

I. **Grinding:** Mainly used on edges of the garment such as pocket edges and pocket hems. This is done by running the edges against abrasion surface or stone to achieve worn out effect. Normally pen type of stone tools are used for small production. For large production, fixed grinding machines are used. In this machine the operator rubs the edges to rotating stone wheel to get the effect.

II. **Abrasion:** This is done on desired areas of jeans by pen type of stone tools. If the tool is driven warp wise, weft will be visible. On the other hand, if the tool is driven weft wise, warp will be visible. As there is no color contrast, it will not be as clearly visible as weft.

III. **Hole:** A hole is created on the garment with cutter or other tools.

IV. **Scratching:** Garment is scratched with sharp tool. Scratching is normally done warp wise or horizontally.

V. **Needle effect or cuts:** Effect is created by cutting the warp yarn by knife, so that weft yarn becomes visible. Needle is also used to tear out fiber warp wise.

Figure 4 Damage effects on denim

Spots

Spots is another kind of dry washing which is done by different method. This is also depending on fabric types and buyer requirements. As shown is Figure 5 spot effects on denim fabric.

Objects

- Spot is the process by which we will get the spot or design.
- The design is made raw denim color so this process is done at unwashed condition.

Types

I. **PP spot and bleach spot:** Spots are created with PP (Potassium permanganate) or bleach solution. Process depends on the type of fabric.

II. **Color spot:** Spots are created with pigment color. Oven process (curing is needed to fix permanently the pigment on the garment).

III. **Silicon spot:** Spots are created with silicon. It creates dirty or wet effect on the garment.

Figure 5 Spot effects on denim

Rubbing

Rubbing is usually done in combination with spraying. This process allows to give more contrast and highlight some part of the garment, especially on waistband or on top of tacking effect as shown in Figure 6.

Objects

- Rubbing is done for more contrast effect on the fabric surface.
- This process focus tacking effect on the fabric.

Types

I. **Rub pigment:** A sponge or piece of fabric is soaked into the solution then rubbed on the garment.

II. **Rub PP (Potassium permanganate):** Rubbing PP gives more contrast effect than PP spray. Normally PP is rubbed to highlight tacking effect.

III. **Rub bleach:** A sponge is soaked into bleach solution then rubbed on the garment.

Figure 6 Rubbing effects on denim

Tacking

Tacking is done by swift tag machine. Garment is folded three, four or five times and tacked or locked through folds. Then the garment is washed and dried. Permanent fold appears after removal of tag pin. The inner of the fold is dark due to less exposure of rubbing and chemicals. Faded effect come on the folded parts. Most favorite areas are waistband, bottom hem, back pocket, back yoke and front pocket corners as given in Figure 7.

Objects

- Tacking is doing on garment for fashion and value added fashion wear.
- Tacking process doing by tagging machines.
- It is doing also by needle, thread and manually.

Figure 7 Tacking effects on denim garments

Wet or chemical washing process:

Wet or chemical washing process is one of most widely used process, which can be done by using different types of chemical and garments loading washing machine are called wet process or chemical process [13, 14].

Types of wet washing process applied in garments:

- Normal wash or rinse wash
- Pigment wash
- Caustic wash
- Silicon wash
- Stone wash
- Bleach wash
- Enzyme wash
- Stone enzyme wash
- Acid wash

Normal wash or rinse wash

Normal washing is the most common, simplest and popular washing process with lowest washing cost. It is nearly mandatory from every buyer. In normal wash manufacturing process, some unwanted materials like dirt, dust and starch are removed without any shrinkage. By altering temperature, time and detergent quantity washing effect could be varied in garments surface. Normal washing also known as different name such as detergent wash, common wash and rinse wash as shown in Figure 8.

Objects

- To remove dust, dirt, oil spot, impurities from the garments.
- To remove size materials from the garments.
- To remove starch presents on the garment fabrics.
- For soft feeling to wear the garments after purchasing.
- To achieve buyer washing standard.

Figure 8 Normal wash

Table 1. Normal or rinse washing process.

Process	Steps	Name of chemicals or product used	Dosage/Quantity
Normal wash	1st step Desizing	Lot size for garments	70 kg
		Add water (L: R = 1: 8)	560 liters
		Machine running.	
		Add detergent (0.5 gm / liter)	280-350 gm
		Temperature	40 ℃ to 60 ℃ or sometimes cold
		Time	5 to 10 min
		Drop the liquor.	
		Cold wash.	
	2nd Step Softening	Add water (L: R = 1: 6)	420 liters
		Machine running	
		Add flax softener (0.6 gm / liter)	252 gm
		Add acetic acid (0.5 gm / liter)	210 gm
		Temperature	40 ℃
		Time	5 to 10 min
		Drop the liquor.	
		Unload the garments on trolley.	
	3rd Step Hydro extracting	To remove excess water from the garment by using hydro extractor machine.	
	4thStep Drying (Steam dryer)	Load on steam dryer	50 kg
		Temperature	60 ℃ - 70 ℃
		Time	40 - 50 min for dry and 10 - 15 min for cold dry
	(or Gas dryer)	Load on gas dryer	50 kg
		Running the machine.	
		Temperature	70 ℃ - 85 ℃
		Time	30 - 35 min for dry and 10 - 15 min for cold dry
	5th Step Quality check	After drying it will be quality checking and good quality garments will be delivery to garments factory.	

Pigment wash

In Figure 9 pigment washing effect is made by pigment dyed or printed garments by pigment washing method. This process is similar to normal washing process. The aim of this washing make fading effect or old looking effect on seam area and also garment surface.

Objects

- To fading affect or old looking effect on garment and also seam area.
- For soft feeling to wear the garment after purchasing.

- To achieve the buyer washing standard.
- To increase the color fastness and rubbing fastness.

Table 2. Pigment washing process.

Process	Steps	Name of chemicals or product used	Dosage/Quantity
Pigment wash	**1st step Desizing**	Lot size for garments	80 kg
		Add water (L: R = 1: 8)	660 liters
		Machine running.	
		Add caustic soda (NAOH)(0.8 gm / liter)	512 gm
		Add soda ash (Na_2Co_3)(1.50 gm / liter)	960 gm
		Add detergent (0.8 gm / liter)	512 gm
		Temperature	50 ℃ to 60 ℃
		Time (Depend upon the shade)	20 to 60 min
		Drop the liquor.	
		Wash 1 time for 5 min by hot wash at the temperature 50 ℃. and wash 1 time by cold water for 5 min.	
	2nd Step Softening	Add water (L : R = 1: 6)	480 liters
		Washing machine running.	
		Add acetic acid (pH 4.5 - 5.5) (0.5 gm / liter)	240 gm
		Add flax softener (0.6 gm / liter)	288 gm
		Add silicon for more slippery hand feel (0.4 gm / liter)	192gm
		Temperature	40 ℃
		Time	15 to 25 min
		Drop the liquor.	
		Unload the garments on trolley.	
	3rd Step Hydro extracting	To remove excess water from the garment by using hydro extractor machine.	
	4th Step Drying (Steam dryer)	Load on steam dryer	50 kg
		Running the machine.	
		Temperature	60 ℃ - 70 ℃
		Time	40 – 50 min for dry and 10 - 15 min for cold
	or Gas	Load on gas dryer	50 kg

	dryer	Running the machine.	
		Temperature	70 ℃ - 85 ℃ for dry
		Time	30 – 35 min for dry and 10 - 15 min for cold
	5th Step Quality check	After drying garments go to quality section and check the garment, good quality garment will be delivery and deep shade again rewash, other quality garment rectify then delivery.	

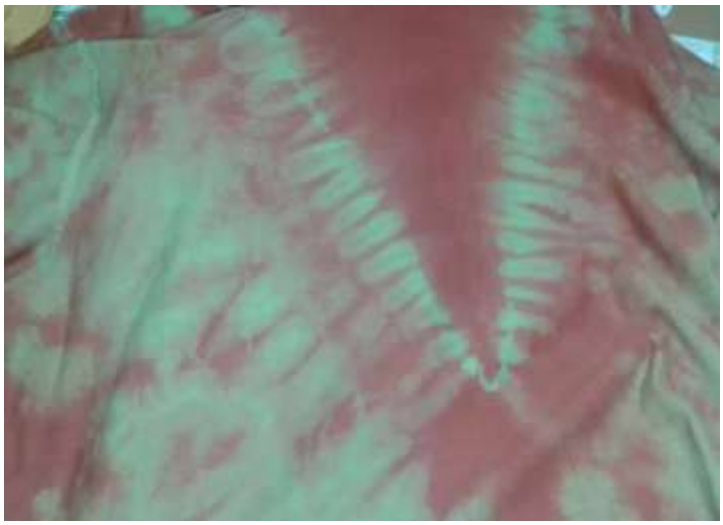

Figure 9 Pigment wash

Caustic wash

Caustic wash generally doing on reactive dye, sulpher dye, direct dyed or printed garments and these fabrics are used to manufacture apparels. This washing process is little bit different from the other process. After some pre-treatment like desizing, scouring and bleaching process usually printing is done on fabric. But caustic washing process, printing is done on the fabric without pre-treatment of the fabric. That is given in Figure 10.

Objects:

- To fading or old looking effect on garment and seam abrasion affection seam area.
- To remove the size materials, starch from the garments.
- To increase the color fastness and rubbing fastness.
- For soft feeling to wear the garments.
- To increase the hairiness on garments.

Figure 10. Caustic wash

Table 3. Caustic washing process.

Process	Steps	Name of chemicals or product used	Dosage/Quantity
Caustic Wash	1st Step Desizing	Lot size garments	80 kg
		Add water (L : R = 1 : 8)	640 liter
		Machine running.	
		Add caustic soda (NAOH) (1.60 gm / liter)	1024 gm
		Add detergent (0.8 gm / liter)	512 gm
		Temperature	50 ℃ - 60 ℃
		Time (Depend upon the shade)	20 to 60 min
		Drop the liquor.	
		Wash cold water for 3 min.	
	2nd Step Neutralization	Add water (L : R = 1: 5)	400 liter
		Add acetic acid (1 gm / liter)	400 gm
		Temperature	40 ℃
		Time	5 min
	3rd Step Softening	Add water (L : R = 1 : 6)	480 liter
		Machine running.	
		Add acetic acid (0.5 gm / liter)	240 gm.
		Add flax softener (0.6 gm / liter)	288 gm
		If more soft use silicon (0.4 gm / liter)	192 gm.
		Temperature	40 ℃
		Time	10 to 20 min
		Drop the liquor.	
		Unload the garments on trolley.	

	4th Step Hydro extracting	To remove excess water from the garment by using hydro extractor machine	
	5th Step Drying (Steam dryer Or Gas dryer)	Load on steam dryer	50 kg
		Running the machine.	
		Temperature	60 ℃ - 70 ℃
		Time	40 - 50 min for dry and 10 - 15 min for cold dry
		Load on gas dryer	50 kg
		Running the machine.	
		Temperature	70 ℃ - 85 ℃ for dry
		Time	10 - 15 minutes for cold dry
	6th Step Quality check	After drying garments go to quality section and check the garment, good quality garment will be delivery and deep shade again rewash, other quality garment rectify then delivery.	

Silicon Wash

Silicon wash is most common and popular washing process. It can be applied almost all types of fabric such as knit, denim, canvas and twill fabrics. This washing process gives more softness and elastic hand feel. In silicon washing process, silicon and softener are used together is shown in Figure 11.

Objects

- It gives durable softness, elastic handle,
- It helps to anti pilling affects, dimensional stability and tear resistance.
- It helps to fabrics to be cut and sewn more easily allows and improving wears and easy care properties.

Table 4 Silicon washing process

Process	Steps	Name of chemicals or product used	Dosage/Quantity
Silicon Wash	**1st Step Desizing**	Lot size garments	60 kg
		Add water (L: R = 1: 10)	600 liter
		Machine Running.	
		Add desizing agent (0.6 gm / liter)	360 gm
		Add detergent (0.5 gm / liter)	300 gm
		Temperature	50 ℃
		Time	10 to 20 min
		Drop the liquor.	
		Rinse one time 3 min.	

	2nd Step Softening	Add water (L : R = 1 : 8)	480 liters
		Add acetic acid (0.6 gm / liter)	288 gm
		Cationic softener (1 gm / liter)	480 gm
		Silicon (ME) (0.5 gm / liter)	240 gm
		Temperature	40 ℃
		Time	15 to 20 min
		Drain the bath.	
	3rd Step Hydro extracting	To remove excess water from the garment by using hydro extractor machine.	
	4th Step Drying (Stem or Gas dryer)	Load garments to gas/steam dryer.	60 kg
		Temperature	75 ℃ to 85 ℃
		Run about	35 to 45 min
		After run for cold dryer	10 to 15 min
	5th Step Quality check	After dryer garment go to quality section for quality checking and then delivery.	

Figure 11 Silicon wash

Enzyme wash

In Figure 12 enzyme wash generally cellulose enzyme are used. So they are bio chemical substances that behave as catalysts toward specific reactions. This washing process is applied heavy fabrics like jeans and denim. Due to enzymatic abrasion, dye is released from yarns, giving contrasts in the blue color on denim fabrics surface. Enzyme washing method almost replaced stone wash.

Objects

- To remove the size materials from the garments.
- To remove the starch presents on the garments fabrics.

- To achieve the high low abrasion (stone affect) on garment and seam abrasion in sewing area.
- Enzyme attack as chemically not mechanically for this reason low damage or wastage then stone wash.
- For soft feeling to wear the garment.
- Especially develop the bio-polishing effect of cotton or denim.
- Enzyme attacks more the surface of the fabrics and gives a very smooth surface.

Table 5 Enzyme washing process

Process	Steps	Name of chemicals or product used	Dosage/Quantity
Enzyme wash	**1st Step Desizing**	Lot size (Twill/canvas garment)	60 kg
		Add water L : R = 1 : 10	600 Liter
		Machine running.	
		Add desizing agent (0.6 gm / liter)	360 gm
		Add detergent (0.5 gm / liter)	300 gm
		Temperature	50 ℃
		Time	10 to 20 min
		Drop the liquor.	
		Rinse one time	3 min
	2nd Step Enzyme	Add water (L : R = 1 : 8)	480 liter
		Temperature	45 ℃
		Add acetic acid (0.5 gm / liter)	240 gm
		Add acid enzyme (1.2 gm / liter)	576 gm
		Add antistain (0.50 gm / liter)	240 gm
		Time (Depend upon the standard)	30 to 60 min
		Increase temperature to 90 ℃ and run 1 minute.	
		Drain the bath.	
		Rinse twice, each 3 min.	
	3rd Step Softening	Add water (L : R = 1 : 8)	480 liters
		Add acetic acid (0.6 gm / liter)	288 gm
		Cationic softener (1 gm / liter)	480 gm
		Silicon (ME) (0.5 gm / liter)	240 gm
		Temperature	40 ℃
		Time	15 to 20 min
		Drain the bath.	
		Then unload the garments on trolley.	
	4th Step Hydro extracting	To remove excess water from the garment by using hydro extractor machine.	
	5th Step Drying (Steam or Gas dryer)	Load garments to gas/steam dryer	60 kg
		Temperature set	75 ℃ to 85 ℃
		Run about 35 to 45 min.	
		After run 10 to 15 minutes for cold dryer.	
	6th Step Quality check	After dryer garment go to quality section for quality checking and then delivery.	

Figure 12 Enzyme wash

Stone wash

Stone wash is done to produce fading and discolor effect on garments surface by stone. In stone wash stone are perforated and that are produced from volcanic explosion. This stones are also called pumice stone. The washing process is also applied on heavy fabric like denim and jeans to create aged and worn out appearance is given in Figure 13. Various kind of washing effect can be achieved by changing the amount of liquor ratio, stones size and shape of stones, cycle time, chemical addition and garment load.

Objects

- The pumice stones act a brushing action on the fabric surfaces.
- The areas where more brushing action take place, there more fading or discolor effect will be developed and the areas where less brushing action takes place, there less discolor effect will be developed.
- The multi-layer fabric areas like, collar, cuff, pocket, placket, side seams etc. areas will be brushed more than the single layer areas.
- As a result, irregular fading is developed in the garments by the action of pumice stones.

Figure 13 Stone wash

Table 6. Stone washing process.

Process	Steps	Name of chemicals or product used	Dosage/Quantity
Stone	**1st step**	Batch size for denim long pant	60 kg

Wash	**Desizing**	Add water (L: R = 1 : 9)	540 liters
		Start the machine.	
		Temperature	60 ℃
		Add desizing agent (0.6 gm / liter)	324 gm
		Add detergent (Antistain) (1 gm / liter)	540 gm
		Time	15 to 25 min
		Drop the liquor.	
	2nd step Hot wash	Add water (L: R = 1: 9)	540 liters
		Temperature	60 ℃
		Time	5 min
	3rd Step Bleaching	Add water (L : R = 1 : 8)	480 liters
		Machine running.	
		Add bleaching powder (k.c.i) (10 gm/liter)	4800 gm
		Add soda ash (5 gm/liter)	2400 gm
		Pumic stone ½ volume of garments.	
		Temperature	60 ℃
		Time (Depend upon the shade)	12 to 15 min
		Drop the liquor.	
		Rinse twice, each 3 minutes.	
	4th Step Neutralization	Add water(L: R = 1: 9)	540 liters
		Add sodium hyposulphite (3 gm/litre)	1620 gm
		Temperature	40 ℃.
		Time (Depend upon the shade)	10 to 12 min
		Drop the liquor.	
		Rinse one	
	5th Step Softening	Add water (L: R = 1: 8)	480 liters
		Add Acetic Acid (0.6 gm/liter)	288 gm
		Cationic softener (1gm/liter)	480 gm
		Time	5 min
		Temperature	40 ℃
		Drop the liquor.	
		Unload the garments to trolley.	
	6th Step Hydro	To remove excess water from the garment by using	

	extracting	hydro extractor machine.	
	7th Step Drying	Load garments on dryer	40 kg
		Temperature	75 ℃ to 85 ℃
		Time	35 to 40 min and 10 minutes in cold dry.
	8th Step Quality check	After quality checking garment will be delivery.	

Stone enzyme wash

In garments washing industry stone enzyme washing becoming very popular day by day. In stone enzyme washing process stone and enzyme wash are applied together as shown in Figure 14.

Table 7. Stone enzyme washing process

Process	Steps	Name of chemicals or product used	Dosage/Quantity
Stone Enzyme Wash	**1st step Desizing**	Batch size for denim long pant	60 kg
		Add water (L: R = 1 : 9)	540 liters
		Start the machine.	
		Temperature	60 ℃
		Add desizing agent (0.6 gm / liter)	324 gm
		Add detergent (Antistain) (1 gm / liter)	540 gm
		Time	15 to 25 min
		Drop the liquor.	
	2nd step Hot wash	Add water (L: R = 1: 9)	540 liters
		Temperature	60 ℃
		Time	5 min
	3rd Step Enzyme	Add water (L : R = 1 : 8)	480 liters
		Add pumic stone ½ volume of garments,	
		Add enzyme (1.50 gm/liter)	720 gm
		Add acetic Acid (0.6 gm/liter)	288 gm
		Add antistain (0.8 gm/liter)	384 gm
		Temperature	40 ℃ to 50 ℃
		Time (Depend upon the shade)	60 to 70 min
		Then temperature raise to 90 ℃ for 1 minute.	
		Drop the liquor.	
		Rinse twice, each 3 minutes.	
		Then pumic stone out from washing machine.	
	4th Step Bleaching	Add water(L: R = 1: 8)	480 liters
		Machine running.	
		Add bleaching powder (k.c.i) (10 gm/liter)	4800 gm

		Add soda ash (5 gm/liter)	2400 gm
		Temperature	60 ℃.
		Time (Depend upon the shade)	12 to 15 min
		Drop the liquor.	
		Rinse twice, each 3 minutes.	
	5th Step Neutralization	Add water (L: R = 1: 9)	540 liters
		Add sodium hyposulphite (3 gm/liter)	1620 gm
		Temperature	40 ℃
		Time	10 to 12 min
		Drop the liquor.	
		Rinse one.	
	6th Step Softening	Add water (L : R = 1 : 8)	480 liter
		Add Acetic Acid (0.6 gm/liter)	288 gm
		Cationic softener (1 gm/liter)	480 gm
		Temperature	40 ℃
		Time	5 min
		Drop the liquor.	
	7th Step Hydro extracting	To remove excess water from the garment by using hydro extractor machine.	
	8th Step Drying	Load garments	40 kg
		Temperature	75 ℃ to 85 ℃
		Time	35 to 40 min
	9th Step Quality check	After quality checking garment will be delivery.	

Figure 14. Stone enzyme wash

Bleach wash

Bleaching of garments means lightening the color of the indigo dyed garments and apparels are normally dyed with direct or reactive dye. It is also a separate process, which can be applied instead of stone washing or together with stone washing. To avoid yellowing problems this process must be followed by the neutralization process is given in Figure 14.

Objects

- Partial color fading effect is produced
- Bleaching is also done after enzyme wash or with stone wash to get more fading effect or super light shade.

Figure 15. Bleach wash

Table 8. Bleach washing process

Process	Steps	Name of chemicals or product used	Dosage/Quantity
Bleach Wash	**1st Step Desizing**	Batch size for long denim pant	60 kg
		Add water (L: R = 1: 9)	540 liters.
		Start the machine.	
		Temperature	60 ℃
		Add desizing agent (0.6 gm / liter)	324 gm
		Add detergent (Antistain) (1 gm / liter)	540 gm
		Time	15 to 25 min
		Drop the liquor.	
	2nd Step Hot wash	Add water (L: R = 1: 9)	540 liters
		Temperature	60 ℃
		Time	5 min
	3rd Step Bleaching	Add water (L: R = 1: 8)	480 liters
		Machine running.	
		Add bleaching powder (k.c.i) (10 gm/liter)	4800 gm
		Add soda ash (5 gm/liter)	2400 gm
		Temperature	60 ℃
		Time (Depend upon the shade)	12 to 15 mts
		Drop the liquor.	
		Rinse twice, each 3 minutes.	
	4th Step Neutralization	Add water (L: R 1: 9)	540 liters
		Add sodium hyposulphite (3 gm/liter)	1620 gm
		Temperature	40 ℃
		Time (Depend upon the shade)	10 to 12 min
		Drop the liquor.	

		Rinse one.	
	5th Step Softening	Add water (L: R = 1: 8)	480 liters
		Add acetic acid (0.6 gm/liter)	288 gm
		Cationic softener (1 gm/liter)	480 gm
		Temperature	40 ℃
		Time	5 min
		Drop the liquor.	
		Unload the garments to trolley.	
	6th Step Hydro extracting	To remove excess water from the garment by using hydro extractor machine.	
	7th Step Drying	Load garments on dryer machine	40 kg
		temperature	75 ℃ to 85 ℃
		Time	35 to 40 min and 10 minutes in cold dry
	8th Step Quality check	After quality checking garment will be delivery.	

Acid wash

It is normally done on the garments from heavy fabrics like denim, course canvas and twill etc. During Acid wash, pumice stones are used. By the action of pumice stones, irregular fading affect is developed on the garments surface is in given in Figure 16. The pumice stones act a brushing action on the garment fabric surface.

Objects

- To produce irregular fading effect or old looking effect.
- For soft feeling to wear the garments i.e. to improve softness.
- To increase rubbing fastness.

Table 9 Acid washing process

Process	Steps	Name of chemicals or product used	Dosage/Quantity
Acid Wash	**1st Step Desizing**	Batch size for long denim pant	60 kg
		Start Machine.	
		Add desizing agent (1 gm/liter)	600 gm
		Add detergent (1 gm/liter)	600 gm
		Temperature	60 ℃
		Time	20 min
		Rinse one for 3 minutes (cold).	
	2nd Step Hot wash	Add water (L: R = 1: 10)	600 liters
		Temperature	60 ℃
		Time	5 min
		Drop the liquor.	
		Unload the garments from the washing machine in the trolley.	
		Load the pretreated garments in the dryer machine.	
		Dry the garment completely and unload the garments.	

	3rd Step Stone preparation	The pumice stones used for acid wash need to pre-treat.	
	4rd Step Cleaning	Batch weight	70 kg
		Add water (L: R = 1: 8)	560 liters
		Add detergent (1 gm/liter)	560 gm
		Temperature	40 ℃ - 50 ℃
		Time	10 min
		Drop the liquor.	
	5th Step Neutralization	Add water (L: R = 1: 8)	560 liters
		Machine running.	
		Add Metabisulphite (5 gm/liter)	2800 gm
		Cold temperature.	
		Time	5 min
		Drop the liquor.	
	6th Step Softening	Add water (L: R = 1: 7)	490 liters
		Machine running.	
		Add Acetic acid (0.6 gm/liter)	294 gm
		Add Softener (1 gm/liter)	490 gm
		Then unload the garments.	
	7th Step Hydro extracting	To remove excess water from the garment by using hydro extractor machine.	
	8th Step Drying	After hydro extraction the garments are sent to drying machine for complete drying.	
	9th Step Quality check	After drying the garments go to quality checking and rectify washing fault and then good one delivery.	

Figure 16 Acid wash

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Conclusion

The scope of garments washing like dry and wet washing process is very broad in textile industry. Under this investigation it is clear that after washing garments are gathered some properties like appearance, softness, comfort and strength because unwashed garments are almost stiff and rough. Now a day, every garments industry tries their level best to produce quality product but that industries are survive and prosper who can produce best quality products at a competitive price. It is further noted that trends are changed very quickly as per customer demand so to meet the desire of them washing process are able to open new market. To achieve the ultimate destination more research and development on garments washing are mandatory. This article will help to do more research to develop multi qualitative product comparatively in excisable price.

References

1. Brenner RA, Hardaway AH. High performance washing process for vertical axis automatic washer. 1988
2. Pazarlıoğlu NK, Sariişik M, Telefoncu A. Laccase: Production by trametes versicolor and application to denim washing. ***Process biochemistry***. 2005, 40:1673-1678
3. Sarkar J, Khalil E. Effect of industrial bleach wash and softening on the physical, mechanical and color properties of denim garments. ***IOSR Journal of Polymer and Textile Engineering***. 2014, 1:46-49
4. Molnar BD, McGrath DT, Dausch ME, Badami VV, Whipple III W. Machine for cleansing articles. 1994
5. Li S, Lewis JE, Stewart NM, Qian L, Boyter H. Effect of finishing methods on washing durability of microencapsulated aroma finishing. ***The Journal of The Textile Institute***. 2008, 99:177-183
6. Yang H-C, Wang W-H, Huang K-S, Hon M-H. Preparation and application of nanochitosan to finishing treatment with anti-microbial and anti-shrinking properties. ***Carbohydrate Polymers***. 2010, 79:176-179
7. Kalliala E, Talvenmaa P. Environmental profile of textile wet processing in finland. ***Journal of Cleaner Production***. 2000, 8:143-154
8. Cavaco-Paulo A. Mechanism of cellulase action in textile processes. ***Carbohydrate Polymers***. 1998, 37:273-277
9. Cassano A, Molinari R, Romano M, Drioli E. Treatment of aqueous effluents of the leather industry by membrane processes: A review. ***Journal of Membrane Science***. 2001, 181:111-126
10. Ricci F. Method of producing a random faded effect on cloth or made-up garments, and the end-product obtained by implementation of such a method. 1988
11. Tarhan M, Sarıışık M. A comparison among performance characteristics of various denim fading processes. ***Textile Research Journal***. 2009, 79:301-309
12. Card A, Moore MA, Ankeny M. Garment washed jeans: Impact of launderings on physical properties. ***International Journal of Clothing Science and Technology***. 2006, 18:43-52
13. SPEAKMAN J, Davidson A, Preston R. Shrink-resisting wool: Some novel features and the description of a new process. ***Journal of the Textile Institute Proceedings***. 1956, 47:P685-P707
14. Chen H-L, Burns LD. Environmental analysis of textile products. ***Clothing and Textiles Research Journal***. 2006, 24:248-261