An Investigation of Eco-friendly Enzyme Washing Process in Denim Apparel

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Abstract

Denim garment is the most preferred of today's youth. This project presents the effect of enzyme & enzyme stone washes using cellulose enzyme on the properties of denim garments to develop novel design and fashion. Three parameters in enzyme washing namely concentration of enzyme, washing temperature and time at pH 5.5 were considered. To investigate the optimum washing condition, indigo dyed cotton denim garments were chosen and processed by enzyme with the concentration of 0.5% to 3.5%, temperature 40°C to 70°C and time 20 min to 60 min for the achievement with desired worn and aged effect. The effect of each parameter is discussed, and denim garment's properties like tensile strength, elongation at break, weight loss, stiffness, water absorption, shrinkage, color fading and morphological values by SEM were evaluated. The optimized washing condition for the best value is 2% enzyme concentration at 55°C for 40 min.

As denim is one of the tradition item and the denim washing have very stable performance.

However, there are some of the comments that when the fabric has longer washing time, use of the chemical on the washing procedure will affect the physical performance such as the tensile strength will decrease.

In order to achieve an optimum the effect of washing process on the denim woven fabric in different washing time, Enzyme Wash, Enzyme wash with bleach, Enzyme wash with stone and Enzyme wash with stone and bleach were carried out for cotton and cotton - spandex denim fabric. The effect of the washing parameters, such as the temperature, time and pH on the result of the cotton and cotton spandex denim after treatment were studied by assessment of the tensile physical properties and elongation to break.

The study concluded that cellulase treated in cotton and cotton denim got a larger various change than the original denim. The cellulase treatment decreases the strength of the properties of the tensile strength and elongation to break

Keywords — *Denim, Enzyme, Washing, Eco-friendly*

INTRODUCTION

Eco-Friendly:

Environmentally friendly, environment-friendly, eco-friendly, nature-friendly, and green are marketing claims referring to goods and services, laws, guidelines and policies that inflict reduced, minimal, or no harm at all, upon ecosystems or the environment. Companies use these ambiguous terms to promote goods and services, sometimes with additional, more specific certifications, such as eco-labels. Their general use as euphemisms can be referred to as green washing.

The International Organization for Standardization has developed ISO 14020 and ISO 14024 to establish principles and procedures for environmental labels and declarations that certifiers and eco-labelers should follow. In particular, these standards relate to the avoidance of financial conflicts of interest, the use of sound scientific methods and accepted test procedures, and openness and transparency in the setting of standards

Objectives of the research:

The purpose of our project to create a new effect on denim apparel, assess the effect of denim washing parameter denim fabric on physical properties & to compare the physical properties of the denim after washing with another types of denim wash.

Discussion

Enzyme wash:

Originally developed as a more environmentally-friendly alternative to stone washing, enzyme washing uses cellulose enzymes to "eat away" at the exposed cellulose, loosening some of the indigo dye particles and giving the denim a worn, aged look. Once the desired effect is achieved, the temperature or alkalinity of the bath can be changed to stop the enzymes. Because it does not physically abrade the fibers, enzyme washing does not weaken the denim; instead, it simply makes the material softer and suppler.

Enzyme washing is a laundering process which uses enzymes to soften and finish fabric; providing jeans and other garments with a worn-in look and feel. The use of enzymes comes with various benefits both economically and environmentally. Enzyme can be used for garment washing as well as fabric washing. Enzymes are proteins produced by living organisms. Some enzymes can be replicated in the laboratory, or engineered to perform in a specific manner. Enzyme washing is ecologically friendly due to the natural origins of enzymes, which biodegrade, instead of lingering in the water supply. Additionally, Enzyme washing products are much more potent than other laundry products, calling for far less volume in terms of quantity.

There are different types of enzymes which are suitable for treating fabric stains and fabric stain removal. In all cases, the enzyme washing process breaks the stain down into smaller molecules which can then be removed. Enzyme washing also produces a softer, more supply garment.

For delicate fabrics, enzyme washing can be an excellent way to get clothing fresh and clean without harming the garment. Enzymes also function at low temperatures, making them suitable for cold wash only fabrics. Many detergent products manufacturers blend enzymes into their formulas, to ensure that they work at all temperatures.

Clothing manufacturers often use enzyme washing to make garments appear aged and worn, especially with denim jeans making them look broken in and used. The enzymes will not affect the strength of the fabric, but they will make the denim softer and more worn looking.

Methodology

Enzyme wash:

Steps & process of enzyme wash:

The enzyme washing process of batch of 60 kgs denim men's long pants (Trouser) are described below:

First Step: Desizing

1. Lot weight (80 pes) ..... 60 kg denim long pant.
2. Add water @ L : R = 1 : 9 ..... 540 Liter
3. Machine Running.
4. Temperature..... 60°c.
5. Add Desizing agent @ 0.6 gm / liter ..... 324 gm.
6. Add Detergent @ 0.8 gm / liter..... 432 gm.
7. Time.....10--20 mins.
8. Drop the liquor.
9. Wash 1 time by cold water.

Second Step: Enzyme

1. Add water @ L : R = 1 : 8 ..... 450 Liter
2. Temperature..... 45°c.
3. Add Acetic Acid @ 0.6 gm / liter ..... 270 gm.
4. Add Anti back staining @ 0.6 gm / liter..... 270 gm.
5. Add Acid Enzyme @ 2.00 gm / liter ..... 900 gm.
6. Time ..... (Depend upon the shade)...40--60 mins.
7. Increase temperature to 90°c and run 1 minute (enzyme killing).
8. Drain the bath.
9. Rinse Twice, each 3 minutes.

Third Step: Softening

1. Add water @ L : R = 1 : 8 ..... 450 Liter.
2. Add Acetic Acid @ 0.6 gm / liter ..... 270 gm.
3. Cationic Softener @ 1 gm / liter..... 450 gm.
4. Temperature..... Cold.
5. Time ..... 15 to 20 mins.
6. Drain the bath.
7. Then unload the garments on trolley.

Fourth Step: Hydro extractor Machine

Fig: Hydro extractor Machine

After unloading garments from the washing machine then they are sent to hydro extractor machine to remove excess water from the washed garments.

Fifth Step: Drying Machine

1. Load 60 kg garments to gas dryer.
2. Temperature set -75°c to 85°c.
3. Run about 40 mins.
4. After then run 10 mins in cold dryer.

Fig: Denim pant before Enzyme wash

Fig: Denim pant after enzyme wash

Genesis Washing LTD
Wash Formula

Buyer :Jacks&Jone **Date:23.01.15**

Style: Rick org GE-123 (Dark) **Wight: 30 kg**

PO.NO: **QTY:66 pcs**

Step	Water	Chemical	Quantity	Time	Temper	Remarks
Desize	180	Cuastic	350 gm	15 min	50°C	
		H/Peroxide	180 gm			
Rinse	500			1 min		
	Tie Remove					
A.Acid	200	A.Acid	200 gm	2 min		
Rinse	500			1 min		
Enzyme	180	Celio Soft CR	700 gm	15 min	50°C	
		Ab LP	300 gm			
		A.Acid	100 gm			
Rinse	500			1 min		
Rinse	500			1 min		
Bleach	400	Japan	1 Kg	3 min	40°C	
Rinse	500			1 min		
Neutral	400	Meta	800 gm	5 min	40°C	
Rinse	500			1 min		
Rinse	500			1 min		
		Dryer & PP Spray				Wt: 26 Kg
Neutral	400	Meta	800 gm	5 min	50°C	

Rinse	500			1 min		
Rinse	500			1 min		
Tint	200	Yellow RL	0.30 gm	2+2 min	40°C	
		Brown GTL	0.50 gm			
		G-Salt	1500 gm			
		Dryer & Ozon				
Ozon		Offer-32 % -30 Sec:				

Process Sequencess
Whisker
M-Whisker
Brushing
Tagging
Manual Tie
Desize
Tie Opening
Acetic Acid
Enzyme
Bleach
Neutral
Grinding
Damage
PP Spray
Neutral
Glue Patch
Tint

Glue Solution
VA-53-80%
XL-20%
Per body use 20 m

Table 1: Effect of enzyme concentration on the characteristics (physical and mechanical properties) of treated denim garments

Conc. of Cellulase enzyme %	Tensile strength (Kg f)		Dimen-sional stability (shrink) %	Weight of fabric (GSM)	Stiff-ness (cm)	Water absor-ption (%)	Moistur e e content (%)	Moistur e regain (%)	EPI & PPI	Elong ation at break (%)	Colo r shad e (rati-ng)
	Warp										
0.0 Before wash	245 (0)	136 (0)	0	318 (0)	4.5 (0)	126	7.40	7.53	70 x42	L=21 W=16	5
0.5	230 (-6%)	124 (9%)	L=- 4.75 W= 0	326 (+2.5 %)	3.2 (-28 %)	145	8.81	7.95	70 x46	L=36 W=20	4/5
1.0	220 (-10%)	120 (-12%)	L= - 5.6 W= +0.5	328 (+3.0 %)	3.1 (-31 %)	150	8.90	8.20	70 x46	L=37 W=22	4
2.0	205 (-16%)	106 (-22 %)	L= - 6.4 W=+ 0.5	334 (+5.0 %)	2.62 (-42 %)	155	8.92	8.60	69 x46	L=37 W=22	3/4
3.0	190 (-22%)	97 (-29 %)	L= -6.3 W=+1.0	334 (+5.0 %)	2.49 (-45 %)	156	8.93	8.60	69 x46	L=34 W=20	3
3.5	190 (-22%)	91 (-33 %)	L=- 6.3 W=+1.0	330 (+3.7%)	2.49 (-45%)	156	8.93	8.60	69 x46	L=34 W=20	3

Enzyme with Stone wash

Steps and Process of washing of denim apparel with enzyme & stone:

Now in our Bangladesh maximum Denim garment is washing STONE ENZYME WASH. It is most popular wash for Buyer. A process of stone enzyme wash of 60 kg batch of Denim Long Pant as mentioned below:-

First Step:-PRE-TREATMENT / DESIZING

•Batch size..... 60 kg Denim Long Pant.
•Add water @ L: R = 1: 9 ..... 540 litters.

•Start the machine.

•Temperature..... 60°c

•Add Desizing agent @ 0.6 gm / litter..... 324 gm.

•Add Detergent / Anti stain @ 1 gm / litter ..... 540 gm.

•Time..... 15 to 25 mins.

•Drop the liquor.

Second Step:-HOT WASH

•Add water @ L: R = 1: 9..... 540 litters.

•Temperature..... 60°c.

•Time..... 5 mins.

Third Step:-

•Add water @ L : R = 1 : 8 ..... 480 litters.

•Add pumice stone @ ½ vol of garments.

•Add Enzyme @ 1.50 gm/litre ..... 720 Gms.

•Add Acetic Acid @ 0.6 gm/litre ..... 288 Gms.

•Add Anti stain @ 0.8 gm/litter ..... 384 Gms.

•Temperature..... 40°c to 50°c

•Time (Depend upon the shade) ..... 60 to 70 mins.

•Then temperature raise to 90°c for 1 minute.

•Drop the liquor.

•Rinse Twice, each 3 minutes.

•Then pumic stone out from washing machine

Fourth Step:-BLEACHING

•Add water @ L: R = 1: 8..... 480 litters.

•Machine running.

•Add bleaching powder @ 10 gm/litter ....4800 Gms.

•Add soda ash @ 5 gm/litre..... 2400 Gms.

•Temperature..... 60°c.

•Time (Depend upon the shade) ..... 12 to 15 mins.

•Drop the liquor.

•Rinse twice, each 3 minutes.

Fifth Step:-NEUTRAL WASH

•Add water @ L: R = 1: 9 ..... 540 litters.

•Add sodium hypo sulphite @ 3 gm/litre ..... 1620 Gms.

•Temperature..... 40°c.

•Time ..... 10 to 12 mins.

•Drop the liquor.

•Rinse one.

Sixth Step:-SOFT WASH

•Add water @ L : R = 1 : 8 ....480 litter.

•Add Acetic Acid @ 0.6 gm/litter ..... 288 Gms.

•Cationic softener @ 1 gm/litre ..... 480 Gms.

•Time..... 5 mins.

•Drop the liquor.

•Unload the garments to trolley.

Seventh Step:-Hydro extractor Machine

Fig: Hydro Extractor machine

•Hydro extraction the garment to remove excess water from the washed garments.

Eighth Step:-Drying Machine:-

Fig: Drying Machine

–Load 40 kg garments

–Set temperature ..... 75°c to 85°c.

–Time ..... 35 to 40 mins.

–Time ..... 10 minutes in cold dry.

Ninth Step:-Delivery

–After quality checking garment will be delivery.

Genesis Washing LTD

Wash Formula

Buyer :J&J **Date:14.01.15**

Weight: 35 Kg

Style: Otim Pitch &Patch
PO.NO:Long Pant

QTY: 70 Pcs

Step	Water	Chemical	Quantity	Time	Temp	Remarks
Rinse	350			1 min		
Desize	200	Ab Lp	300 gm	10 min	50°C	
		Stone	1 Bag			
Rinse	350			1 min		
		Stone Remove				
Rinse	350			1 min		
		Dry & PP Spray				**Wt:35 kg**
Neutral	300	Mex	600 gm	5 min	50°C	
Rinse	350			1 min		
Rinse	350			1 min		
Tint	200	Brown GTL	3.50 gm	2+2 min	50°C	
		Yellow-RL	0.60 gm			
		G-Salt	2.5 Kg			

Process Sequences
Whisker
Brushing
Desize + Stone
Twist
PP Rubbing in waist belt area

Glue Solution
VA-53-80%
XL-20%
Per body use 20 m

Color Solution

PP
Neutral
Tint
Glue Patch
Color Rubbing by net
Color Spot by net

Black NF--- 0.03%
Brown GTL--- 0.15%
Yellow 2RL--- 0.1%
NK Binder--- 3%
Water--- 96.72%
Per body 20 ml

Advantages of Enzyme Stone Wash:

1. stone (pumice stone)are mostly used for creating abrasion effect on the body of the fabrics.

2. Highly demanded washing effect

3. Stone wash process gives “used” or “vintage” look on the garment, because of varying degree of abrasion in the area such as waist band, pocket, seam & body.

4. To give distressed denim look stone washing is done on denim fabric.

5. In stone washing the worn out look is given purposely.

6. The longer, the process, the lighter would the color of the fabric get, with better contrast.

7. There are many limitation & drawbacks in stone washing which can be overcome by new enzyme based washing technology. This technology also help to conserve water, time, energy & environment

Disadvantages of Enzyme Stone Wash:

1. Machine damage

2. Blocking of the drainage system

3. Difficulty in removing pumice-stone residues

4. Excessive damage to garment hems and seams

5. Large amount of stone required for small batch

Limitations

To perform this project we have faced many of problems & restriction that were occurred with us.

1. First of all, we haven’t any washing machine in our university that’s why we have to perform this project out door.

2. We haven’t got any cost to perform this project from university, so we have to bear it ourselves.

3. For performing it, we got too short time.

4. Washing plants, where we have done our project, was restricted to touch any parts of machinery & products.

5. We hadn’t have sufficient time for visiting the factory.

Findings & Results

Fig: Matching for desired effect & shade

The objectives of the study were achieved. Nevertheless, the different concentration of Cellulase, effect on cotton denim and cotton denim fabric can be investigate in a broader and deeper dimension, physical & mechanical properties in both experiments and evaluation. We got some significant data through analysis which is given in Table-1.

We got some newer effect on denim fabrics due to both enzyme & enzyme with stone wash.

Fig: Different effects of denim fabrics through our analysis.

We have compared the effects of denim pants that are washed by both enzyme & enzyme with stone wash.

Fig: Enzyme & enzyme with stone washed denim pants comparing

Recommendation

In the study, four of the Cellulase washing condition with on enzyme concentration was selected for analysis. The effect of the different levels of the factors such as the different temperatures, pH condition, enzyme concentration, liquor ratios, treatment times and magnitudes of mechanical agitation can be used for the further study.

In the evaluation aspect, the dimensional stability and the fabric weight test was not investigated. As when the fabric there has the high shrinkage for the washing, it will directly affect the tensile properties. Because, the fabric has the high shrinkage after wash, warp and weft yarn will close together and become higher density, and the fabric will become thicker, tensile strength will become strength.

Another measurement that can be assessed is the tear strength and resistance to flex abrasion because there should be fully observation of the fabric properties. It is because tensile strength can't reflect all the properties of the denim fabric.

Conclusion

After the evaluation for the different times of the washing condition & concentration of Cellulase of the cotton fabric and cotton spandex fabric, the result obtain can be concluded.

During the washing, the starch surface fibers and some of the dyestuff were removed by the abrading stone or hot water. The tensile strength of these samples became weaker in both fabric directions. The loss in the durability depended on the processing time, as the longer of the processing time, the lower the durability.

According to the analysis data, it could see the strength of the enzyme wash with stone and bleach was the weaker. This was due to the chemical degradation of cotton and cotton spandex fiber by the oxidizing agent, sodium hypochlorite and the abrasion action of the pumice stone.

In fact, Enzyme wash with stone wash have the bio polishing effect as find out that the original fabric was weaker than the after wash fabric. It was because the Cellulase can increase the biopolishing of the cotton fabric to enhance the handle value. Although the effects of the Cellulase hydrolysis can stay as the surface phenomena, much of the physical aspects of the fabric like the tensile strength take place during the processing.

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