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# Optimizations of Sustainable Washing for Denim Garments by Enzyme Wash & Bleach Wash based on ANOVA -L9 Control- Level Factor Design

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***Abstract:*** The conventional dyeing process requires a substantial amount of auxiliaries and water, which leaches Garments washing is an important process for garments manufacturing which is used to create an uneven and distinctive "well worn" look, and making every garments unique and modify the appearance, outlook, comfort ability and fash-ion of garments is changed. The study focus on enzyme wash and enzyme bleach wash effect by Sustainable Washing Machine. The sample selected for the project is 98% cotton and 2% spandex. Two standard recipes have been prepared for enzyme wash and enzyme bleach wash. The sample has been processed for enzyme wash and enzyme bleach washes with sustainable washing machine. Enzyme wash has been completed with sustainable washing machine. After completing enzyme wash, Enzyme bleach wash has been completed by sustainable washing machine. After completing process sample has been collected from both process and the sample properties has been compared like rubbing properties and tensile properties. After comparing result the color fastness to rubbing of enzyme wash was poor in sustainable machine and rubbing properties of enzyme bleach wash was good in sustainable machine.

***Keywards:*** Denim garments, Sustainable Washing Machine, Enzyme wash, Bleach Wash, Single Factors, L9 design, ANOVA.

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## Introduction

In readymade garments sector garments washing is the new technology. After making garments solid color dyed or pigment printed fabric the garments are washed commercially[1]. A garment washing is an important parts of garments manufacturing. The technology which is used to modify the appearance, outlook, comfort ability and fashion of

garments is changed and old garments effect can be produced[2]. The most commonly denim washing methods are enzyme wash, bleach wash, acid wash, normal wash, etc.

The denim sector is booming worldwide, because of the spread of denim culture. Popularity of denim garments has been increasing day by day in world market but in denim industry 100 liters of water to wash a single pair of jeans during the production process. This translated into the denim industry consuming around 18 billion liters of water per year.

Eco-friendly sustainable is the new technology and it creates a big challenge for our denim industry because popularity of sustainable wash in world market has been increasing day by day[3]. Denim is very strong, stiff and hard wearing woven fabric. Denim garments washing is very important technology to modify the appearance, outlook, comport ability and

create new fashion of garments. Without finishing treatments, denim garment is uncomfortable to wear, due to its weaving and dyeing effects. For this it essentially needs a finishing treatment to make it softer, smooth and comfortable to wear performance[4]. To meet up the quick change of current demands of customers, technologists are trying to introduce new designs and fashion on denim garments by using sustainable washing process. The most commonly denim washing methods are enzyme wash, bleach wash, acid wash, normal wash, etc.

Among the washing methods, bleach method is widely used method in industry especially for denim washing to achieve required color shade by hypochlorite bleaching[5]. Denim Bleach is a process that can be used to decolorize indigo from denim with the help of oxidizing or reducing agents. Bleach effect and discoloration depending on strength of the bleach liquor, temperature and treatment time[6]. It is preferable to have strong bleach with short treatment time.

Enzymes are living organisms which will attack a specific molecular group. The action of enzyme during enzyme wash it hydrolysis the cellulose. At first it attacks the having projecting fibers and hydrolyzed them. Then it attaches the yarn portion of the fabric and partly hydrolyzed the yarn portion. As a result color comes out from the yarn portion and faded affect is produced. In recent years has been increasing interest in the use of environment friendly, nontoxic, fully bio de-gradable enzyme in the modern textile technology finishing process[7]. Enzymatic treatment can replace a number of mechanical and chemical operations, which have been applied to improve the comfort and quality of garments.

In the textile industry enzymes are applied mainly to get a cleaner fabric surface with less fuzz, to reduce tendency to pill formation, to smooth the surface combining with traditional softeners. To improve fabric handle and other valuable properties, softeners are widely used in finishing operations[8].

This washing and fading processes change aesthetic appearances of denim and twill garments deteriorate their mechanical properties, especially strength and durability of the products[9]. Although durability is not one of the main concerns of denim product consumers, wear on fabric because of previously mentioned chemical and mechanical applications may de-crease the necessary performance properties of denim products.

The effect of bleaching wash and enzyme concentration on the physical and mechanical properties for denim wash. The aim of this study modification of denim garments due to applying different enzyme concentration of 1g/L to 3g/L, temperature 45° C and time for 30 minutes. In another work, for same fabric construction, bleaching powder is used with the concentration of 1g/L to 3g/L, temperature 45° C and time for 30 minutes with 30% pumic stone (owg) at temperature 45° C and pH 10.5 for 30 min based on single factor experimental design analysis. The effect on the properties like optimized result both for enzyme wash and bleach wash (Single factor), S/N ratio, residual plots and Interaction plot for GSM. After L9 design we have done also sustainable enzyme bleach wash process were examined and compared such as tensile strength and rubbing test. Finally evaluated result they found the enzymatic wash has more effect on different properties of denim garments than the bleach wash[9]. The tensile strength and elongation at

break is highly affected by Cellulose enzyme than bleaching powder. Enzyme also accelerates more color fading than stone bleach and has more positive effect on creating new look faded fashion denim garments[10].

Denim is very versatile fabric. Blue is the original color of denim but it is also dyed into different colors like black, brown and olive green. Denim is the most commonly used as the main raw material in manufacturing of jeans, but it is als using any stone or by reducing the use of pumice stone. Cellulose enzymes remove the indigo presents in the surface layer of fiber

Enzyme wash is environmental friendly wash due to the natural origins of enzymes. It is also a popular garment washing process. To reduce the adverse effect of stone wash, the garments are washed by using enzymes, enzyme breaks the surface cellulose fibers of the fabric and removes during washing[14].

human demand, choice, fashion etc. are changing rapidly. To meet requirement of apparel users garments washing become essential.

Objective of garments wash:

To remove dust, oil, spot, impurities from the garments.

To remove size materials from the garments.

To remove starch presents on the garment fabrics.

To remove adhering or unfixed dyes from fabrics or garments.

To increase the softness of the garments.

To control the shrinkage of garments.

used for making shirts, jackets, skirts, dresses, hats, handbags and more. The technology which is used to modify the appearance, outlook, comfort ability, and fashion of the garments is called garments washing. With the change of time

Enzyme wash:

Enzyme wash is a bio-catalytic method an ultra-soft handle effect can produced on garment[13]. The hydrolytic effect of enzyme causes the loss of surface fiber, which improves surface smoothness and softness of the garments. Cellulose enzyme are natural proteins which are used in garments washing to achieve stone wash look on the garments without

Objects of Enzyme wash

Enzyme wash is required for the following reasons:-

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/wastage then stone wash.

For soft feeling to wear the garment

To achieve the buyer reference sample.

To increase the color fastness &rubbing fastness.

Especially develop the “Bio-Polishing” affect of cotton/denim.

Enzyme improves the anti-pilling properties.

Enzyme attacks more the surface of the fabrics and gives a very smooth surface.

Advantage of Enzyme washing

Soft handle and attractive clean appearance is obtained without severe damage to the surface of yarn.

Simple process handling and minimum effluent problem.

Better feel to touch and increased gloss or luster.

Prevents tendency of pilling after relatively short period of water.
Can be applied on cellulose and its blend.
Due to mild condition of treatment process is less corrosive.
Fancy colorfleeced surface can be obtained without or a partial use of stone.

Factors affecting Enzyme activity

Substrate concentration the rate of enzyme activity increases with substrate concentration at lowers level up to a certain point and then slows down.
PH value – the amino acids and other ion sable groups in enzyme may get ionized at lower or higher pH affecting its activity.
Temperature – with increase in temperature the reaction rate increases due to "thermal energy", but with further increase in temperature, the rate decreases due to thermal denaturation.

Activators – presence of specific bivalent metal cat-ion can activate enzyme reaction
Inhibitors – certain alkalis, acids and antiseptic tend to inhibit enzyme activity.

Types of Enzyme:
Mainly two types of enzyme used in washing
Acid enzyme
Neutral Enzyme

Neutral Enzyme is two types-
Powder form
Liquid from i.e. SL Enzyme.
Here neutral enzyme is used for enzyme wash
Neutral enzyme:
This type of enzyme works at neutral condition and comparatively a high temperature. Neutral enzyme gives better salt & pepper effect with very less back staining & it's generally comes in powder form & also retains better strength of fabric than acidic cellulose. For mild action attack on cotton (cellulose) fiber it attacks indigo ring dyed cotton fibers on surface of jean which causes surface fibers to break and detach fibers on surface dyed with indigo therefore removed reducing indigo.
Bleach Wash:
The technology which is used to modify the appearance,outlook,comfort ability, and fashion of the garments is called garments washing.Bleach wash is similar to pigment wash. Bleach wash is done mainly on denim garments. Bleach is a chemical that removes colors or whitens, often via oxidation. Common chemical bleaches include household chlorine bleach, a solution of approximately 3–6% sodium hypochlorite (NaClO), and oxygen bleach, which contains hydrogen peroxide or a peroxide-releasing compound such as sodium perborate, sodium percarbonate, sodium persulfate, tetrasodium pyrophosphate, or urea peroxide together with catalysts and activators, e.g.

tetraacetylethylene diamine[15]. To bleach something is to apply bleach, sometimes as a preliminary step in the process of dyeing. Bleaching powder is calcium hypochlorite.

Many bleaches have strong bactericidal properties, and are used for disinfecting and sterilizing. Most bleaches are hazardous if ingested or inhaled, and should be used with care.

Mechanism of bleach action:

Color in most dyes and pigments are produced by molecules, such as beta carotene, which contain chromophores. Chemical bleaches work in one of two ways

An oxidizing bleach works by breaking the chemical bonds that make up the chromophore. This changes the molecule into a different substance that either does not contain a chromophore, or contains a chromophore that does not absorb visible light.

A reducing bleach works by converting double bonds in the chromophore into single bonds. This eliminates the ability of the chromophore to absorb visible light.

3.5.2 Objective of Bleach washes:

To get fading effect on garments.

To increase softness feeling of the garments.

"Wash look" appearance is developed.

## Research Methodology

Materials:

- Fabric type : Denim (indigo)
- Composition : 100% cotton, 2% spandex
- GSM :360

Chemicals:

- Enzyme (Biolase NC -77)
- Anti-back staining agent (BBNTC-1)
- Calcium hypo chloride
- Sodium metaby sulphate

Equipment: The following m/c are used in Salim & Brothers ltd -

- Sample washing Machine (Horizontal / Vertical Type)
- Sustainable washing machine
- Washing Machine (Front loading)
- Hydro extractor Machine
- Dryer Machine (Steam)
- Chemical Mixture Machine
- Industrial Oven (Gas/Electric)
- Tearing Strength Machine
- Tensile Strength Machine

Front Loading Washing Machine:

- Available with complete stainless steel inner & outer drum Front door.
- Long lasting rust free operation.
- Auto timed, auto reverse, auto temperature control.
- Auto Water Level Control
- Electrically operated water & steam valves.

- Separate motors for wash & extract.
- Ideally suited for laundry wash & stone wash.
- Easy loading & unloading through large toughened glass door.

BRONGO Machine:

- Brand Name: BRONGO
- Model No. : L4200
- Speed : 105 Rpm
- Capacity : 120kg


Figure 1: BRONGO Machine

Sustainable Washing Machine:

- Brand Name: Tolker
- Model No. :
- Speed : 600 - 700
- Capacity : 100 KG


Figure 2: Sustainable Washing Machine

Hydro-Extractor Machine:

- Brand Name : SHI-FURE
- Model No: KL42
- Country Origin: Taiwan
- Capacity : 120 kg
- Quantity : 10

Figure 1: Hydro-extractor M/c

Dryer:

The machine which is used for drying the garments is called dryer. They are two types.

- Brand Name :TRIVENETA GRANDI IMPIANTI
- Model No. : E/250
- Country Origin : Italy
- Speed : 100 RPM
- Capacity : 100kg
- Quantity : 10

a) Steam Dryer Machine:

In this dryer steam is converted to heat by using a heat exchanger. Then the heat is applied on garments and dry .this heat exchanger is known as condenser.

b) Gas Dryer Machine:

In this dryer gas is used directly burned and heat is produced .this heat is applied on garment.

Figure 2: Dryer m/c

Crock meter/Rubbing fastness test:

Figure 5: Crock meter/Rubbing fastness test

Tensile Strength Machine:

Figure 6: Tensile Strength machine

**Methodology:**

Collection denim fabric

↓

Enzyme washes by sustainable machine.

↓

Enzyme bleach washes by sustainable machine.

↓

After process compared qualities of sample

Enzyme Washing Process with Sustainable Machine:

Recipe

Fabric Weight=3kg

Neutral Enzyme (Biolase NC -77) = 1 g/L, 2 g/L, 3g/L

Anti-back staining agent (BBNTC-1) = 0.5gm/L

M: L=2 gm/L

PH=7

Temp =45ºc

Time =30 min.

Variable Enzyme Concentration: Single factor experiment design analysis based on variable Enzyme which is given below in Table 1.

| Variable Enzyme | Temperature ($^0$C) | Time(min) |
|---|---|---|
| 1 g/L | 45$^o$c | 30 min. |
| 2 g/L | | |
| 3 g/L | | |

In this above experimental single factor analysis we assume the temperature at 45 0C and time for 30 minute and just var-iable Enzyme Concentration from 1g/L to 3g/L. After washing the process we found the suitable Enzyme Concentration is 2g/L based on visual assessment.

Variable Temperature (0C): Single factor experiment design analysis based on variable Temp which is given below in Table 2.

| Enzyme | Variable Temperature ($^0$C) | Time(min) |
|---|---|---|
| 2 g/L | 35 | 30 min. |
| | 45 | |
| | 55 | |

From the table 1 we got suitable Enzyme Concentration is 2g/L, assume time for 30 minute and variable temperature from 350C to 55 0C. After finishing the process we found the suitable Drying Temp at 450C based on visual assessment.

Changeable Time (Min): Single factor experiment design analysis based on Changeable Time which is given below in Ta-ble 3.

| Variable Enzyme | Temperature ($^0$C) | Variable Time (min) |
|---|---|---|
| 2 g/L | 45$^0$C | 20 |
| | | 30 |
| | | 40 |

From the table 2 we got also suitable temperature at 45 0C and time from 20 minute to 40 minute. After washing the pro-cess we found the suitable time for 30 minutes based on visual assessment.

Optimum data analysis: We got the Optimum results from single factor (based visual assessment) data analysis which is given below in Table 4.

| Variable Enzyme | Temperature ($^0$C) | Time(min) |
|---|---|---|
| 2 g/L | 45$^0$C | 30 |

Enzyme washing process curve:

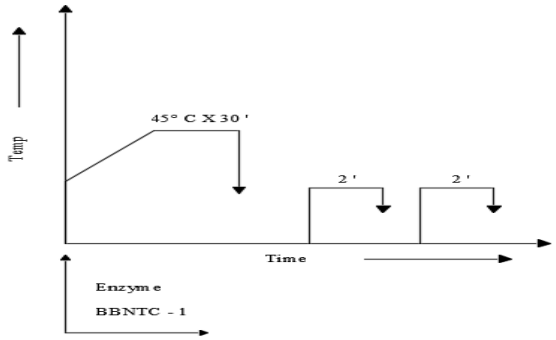



Figure 7: Washing Curve

Flow Chart:

Machine loading with garments and water
↓
Start the machine
↓
Added enzyme and other auxiliaries
↓
Raise the temp.at 45ºc
↓
Continue the process for 30 min.
↓
Drop the bath
↓
Cold rinse for 2 min
↓
Again Cold rinse for 2 min
↓
Hydro- Extractor
↓
Drying

Working process:

- The garments are loaded on the machine.
- Then machine fill with the water according the recipe.
- Then added enzyme and other auxiliaries and rise the temperature at 45ºc and process run 30 minutes.
- After run 30 minutes we drop the bath and two times done cold rinse.
- After completing cold wash then we have taken two garments from the machine then we have completed hydro extractor and drying the garments.

Enzyme Bleach Washing Process with Sustainable Machine:

Recipe:

Fabric Weight=3kg
Calcium Hypochloride (bleaching powder) = 1g/L, 2 g/L, 3g/L
Sodium Meta by Sulphate (Neutralizer) = 0.5g/L
M: L=1:8
$P^H$=7
Temp =45ºc
Time =30 min.

Variable Calcium Hypochlorite Concentration (g/L): Single factor experiment design analysis based on variable Calcium Hypochlorite which is given below in Table 5

| Variable Calcium Hypochloride (g/L): | Temperature ($^0$C) | Time(min) |
|---|---|---|
| 1 g/L | 45$^0$C | 30 min. |
| 2 g/L | | |
| 3 g/L | | |

In this above experimental single factor analysis we assume the temperature at 450C and time for 30 minute and just variable Variable Calcium Hypochloride Concentration from 1g/L to 3g/L .After washing the process we found the suitable Variable Calcium Hypochloride Concentration is 2g/L based on visual assessment

Variable Temperature (0C): Single factor experiment design analysis based on variable Temp which is given below in Table 6.

| Calcium Hypochloride | Variable Temperature ($^0$C ) | Time(min) |
|---|---|---|
| 2 g/L | 35 $^0$C | 30 min. |
| | 45 $^0$C | |
| | 55 $^0$C | |

From the table 5 we got suitable Calcium Hypochloride is 2g/L, assume time for 30 minute and variable temperature from 350C to 55 0C. After finishing the process we found the suitable Drying Temp at 45 0C based on visual assessment.

Changeable Time (Min): Single factor experiment design analysis based on Changeable Time which is given below in Ta-ble 7.

| Calcium Hypochloride | Temperature ( $^0$C ) | Variable Time(min) |
|---|---|---|
| 2 g/L | 45$^0$C | 20 |
| | | 30 |
| | | 40 |

From the table 6 we got also suitable temperature at 45 0C and time from 20 minute to 40 minute. After washing the pro-cess we found the suitable time for 30 minutes based on visual assessment.

Optimum data analysis: We got the Optimum results from single factor (based visual assessment) data analysis which is given below in Table 8.

| Calcium Hypochloride | Variable Temperature ( $^0$C ) | Time(min) |
|---|---|---|
| 2 g/L | 35 | 30 |

Flow Chart:

Machine loading with garments and water

↓

Start the machine

↓

Added Bleaching Powder

↓

Raise the temp at 45ºc

↓

Continue the process for 30 min.

↓

Drop the bath

↓

Cold rinse for 2 min

↓

Drop the bath

↓

Neutralize for 3 min. at RT

↓

Drop the bath

↓

One cold rinse for 2 min

↓

Hydro Extractor

↓

Drying the fabric

Working process:

- The garments are loaded on the machine.
- Then machine fill with the water according the recipe.
- Then added bleaching powder and rise the temperature at 45ºc and process run 30 minutes.
- After run 10 minutes we drop the bath and we have completed cold rinse.
- After completing cold wash then we have neutralize and again completed one cold wash and then garments taken from the machine then we have completed hydro extractor and drying the garments.

**Result & Discussion**

L9 Taguchi Experimental Design analysis:

Recent industrial applications have been particularly associated with the name of the Japanese engineer, G. Taguchi. The Taguchi method optimizes design parameters to minimize variation before optimizing design to hit mean target values for output parameters. The Taguchi method uses special orthogonal arrays to study all the design factors with minimum of ex-periments. The Taguchi method is one of the best experimental methodologies used to find the minimum number of experi-ments to be performed within the permissible limit of factors and levels. The comparative

study was performed for volumet-ric wear of Nano hydroxyapatite and MTA-filled dental composites using a combination of four factors, each having five lev-els. The S/N ratio for the smaller is better characteristic was to find the best condition for the minimum volumetric wear rate.

L9 Taguchi Experimental Design analysis design which is given below in Table 9: L9 Design

| Run | X1 | X2 | X3 |
|---|---|---|---|
| 1 | 1 | 1 | 1 |
| 2 | 1 | 2 | 2 |
| 3 | 1 | 3 | 3 |
| 4 | 2 | 2 | 1 |
| 5 | 2 | 3 | 2 |
| 6 | 2 | 1 | 3 |
| 7 | 3 | 3 | 1 |
| 8 | 3 | 1 | 2 |
| 9 | 3 | 2 | 3 |

Sustainable Enzyme washes which is given below in Table 10:

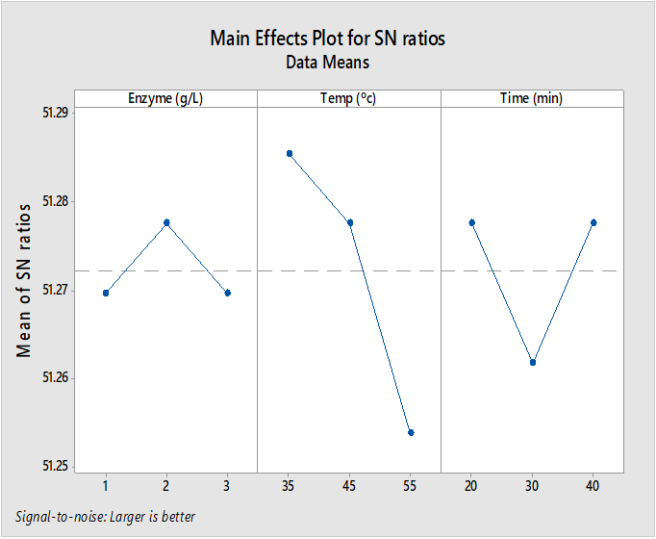
| Enzyme(g/L) | Temp (ºc) | Time (min) | GSM | SNRA1 | MEAN1 |
|---|---|---|---|---|---|
| 1 | 35 | 20 | 367 | 51.2933 | 367 |
| 1 | 45 | 30 | 366 | 51.2696 | 366 |
| 1 | 55 | 40 | 365 | 51.2459 | 365 |
| 2 | 35 | 30 | 366 | 51.2696 | 366 |
| 2 | 45 | 40 | 367 | 51.2933 | 367 |
| 2 | 55 | 20 | 366 | 51.2696 | 366 |
| 3 | 35 | 40 | 367 | 51.2933 | 367 |
| 3 | 45 | 20 | 366 | 51.2696 | 366 |
| 3 | 55 | 30 | 365 | 51.2459 | 365 |

Taguchi Analysis: GSM versus Enzyme (g/L), Temp (ºc), Time (min), Response Table for Signal to Noise Ratios Larger is better

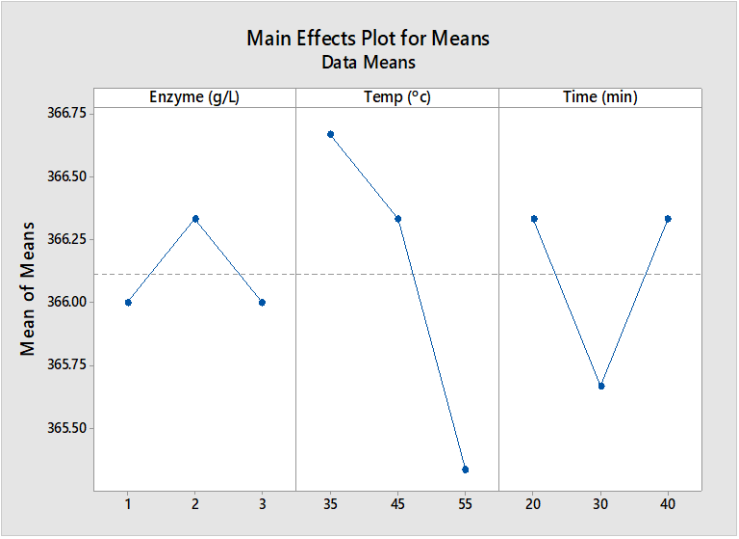
Response Table for Means

| Level | Enzyme (g/L) | Temp (ºc) | Time (min) |
|---|---|---|---|
| 1 | 366.0 | 366.7 | 366.3 |
| 2 | 366.3 | 366.3 | 365.7 |
| 3 | 366.0 | 365.3 | 366.3 |
| Delta | 0.3 | 1.3 | 0.7 |
| Rank | 3 | 1 | 2 |

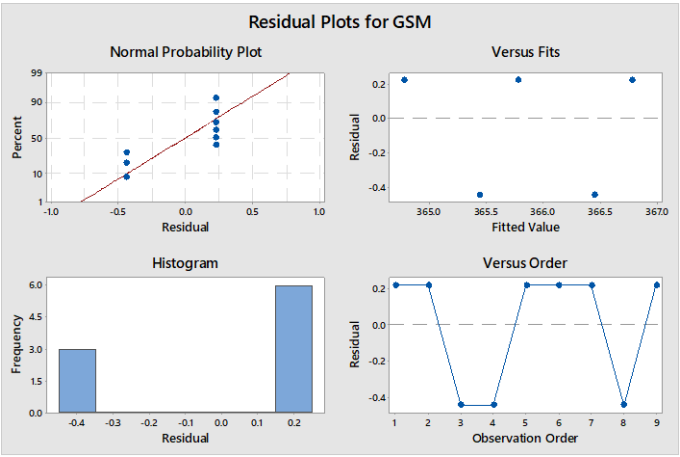
| Level | Enzyme (g/L) | Temp (ºc) | Time (min) |
|---|---|---|---|
| 1 | 51.27 | 51.29 | 51.28 |
| 2 | 51.28 | 51.28 | 51.26 |
| 3 | 51.27 | 51.25 | 51.28 |
| Delta | 0.01 | 0.03 | 0.02 |
| Rank | 3 | 1 | 2 |



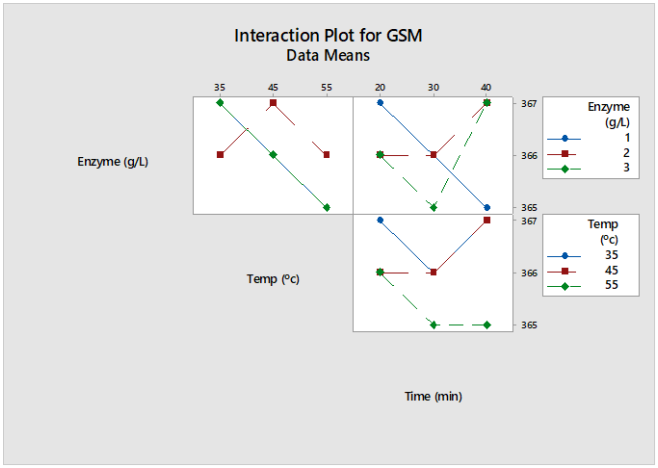

Graph 1: Response for Signal to Noise Ratios




Graph 2: Response for Means




Graph 3: Residual plots for GSM




Graph 4: Interaction plot for GSM

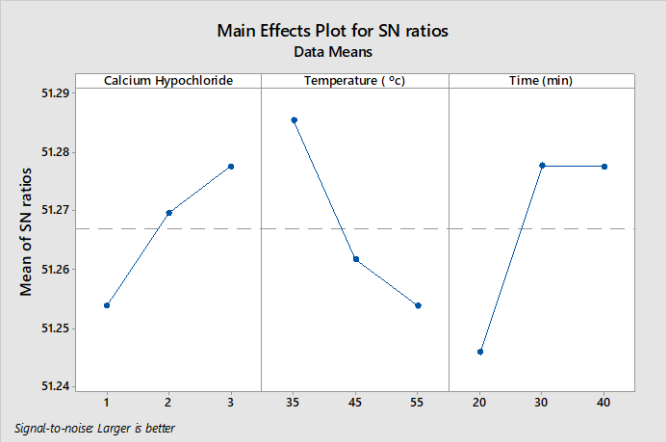
Effect of bleach washes which is given below in Table 11:

| Calcium Hypochloride | Temperature ( ºc) | Time (min) | GSM | SNRA1 | MEAN1 |
|---|---|---|---|---|---|
| 1 | 35 | 20 | 365 | 51.2459 | 365 |
| 1 | 45 | 30 | 366 | 51.2696 | 366 |
| 1 | 55 | 40 | 365 | 51.2459 | 365 |
| 2 | 35 | 30 | 367 | 51.2933 | 367 |
| 2 | 45 | 40 | 366 | 51.2696 | 366 |
| 2 | 55 | 20 | 365 | 51.2459 | 365 |
| 3 | 35 | 40 | 368 | 51.3170 | 368 |
| 3 | 45 | 20 | 365 | 51.2459 | 365 |
| 3 | 55 | 30 | 366 | 51.2696 | 366 |

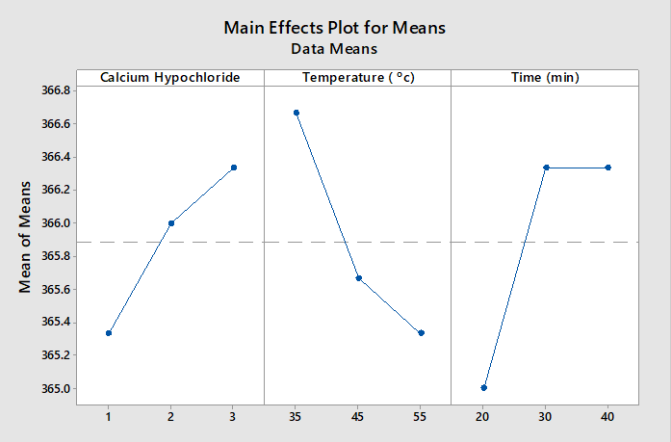
Taguchi Analysis: GSM versus Calcium Hypochloride, Temp(ºc), Time (min), Response Table for Signal to Noise Ratios Larger is better

| Level | Calcium Hypochloride | Temperature ( ºc) | Time (min) |
|---|---|---|---|
| 1 | 51.25 | 51.29 | 51.25 |
| 2 | 51.27 | 51.26 | 51.28 |
| 3 | 51.28 | 51.25 | 51.28 |
| Delta | 0.02 | 0.03 | 0.03 |
| Rank | 3 | 2 | 1 |

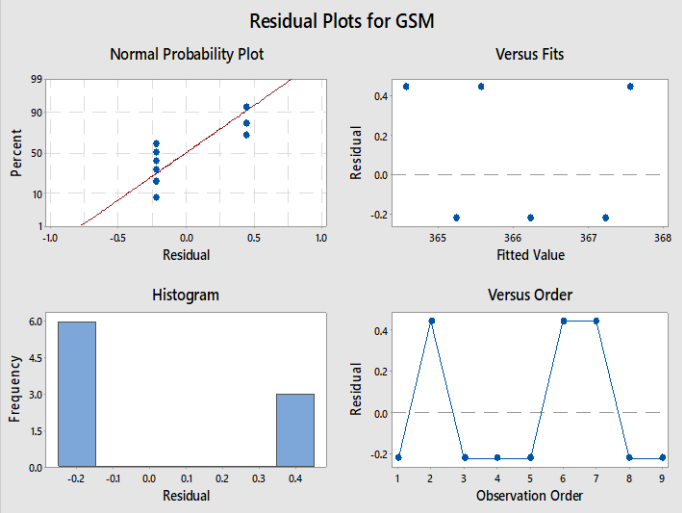
| Level | Calcium Hypochloride | Temperature ( ºc) | Time (min) |
|---|---|---|---|
| 1 | 365.3 | 366.7 | 365.0 |
| 2 | 366.0 | 365.7 | 366.3 |
| 3 | 366.3 | 365.3 | 366.3 |
| Delta | 1.0 | 1.3 | 1.3 |
| Rank | 3 | 1 | 2 |



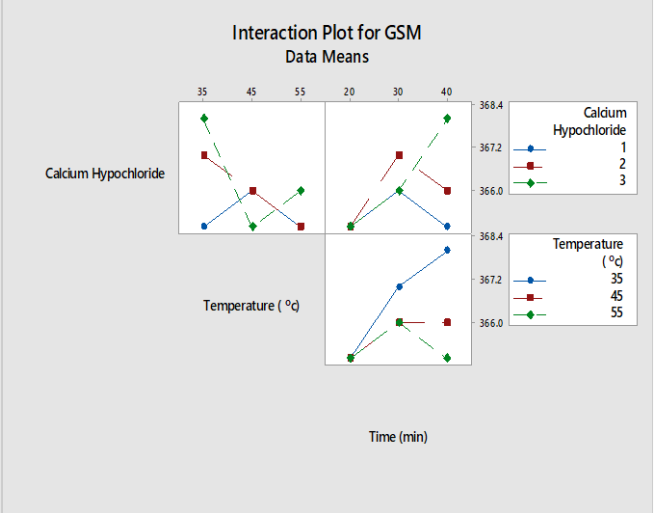

Graph 5: Response for Signal to Noise Ratios




Graph 6: Response for Means




Graph 7: Residual plots for GSM




Graph 8: Interaction plot for GSM

**Effect of enzyme wash:** Enzyme wash effect on denim garments fabric. In this project we have done enzyme wash for 30 minutes at 45°c temperature by sustainable machine. Here in figure given the effect of denim garments fabric before and after wash.

Table 12: Tensile strength Test Result

| Testing Process | Direction | Before Wash | After Process |
|---|---|---|---|
| Sustainable Enzyme Wash | Warp | 972 | 969.67 |
| | Weft | 468.5 | 458.0 |
| Sustainable Enzyme Bleach Wash | Warp | 972 | 958.68 |
| | Weft | 468.5 | 445.2 |

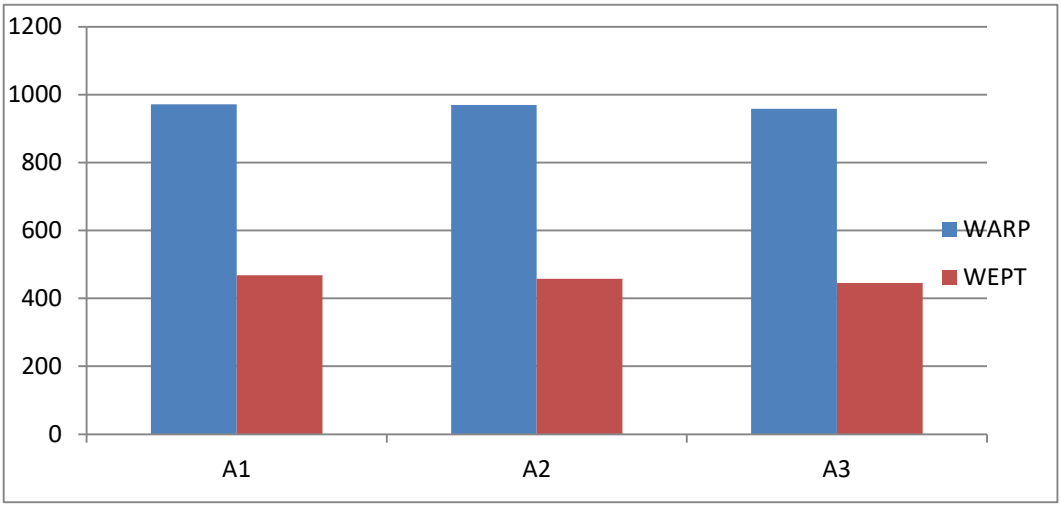
Before wash After wash

Figure 8: Enzyme Wash effect of sustainable machine

**Effect of enzyme bleach wash:** Enzyme wash effect on denim garments fabric. In this project we have done enzyme wash for 30 minutes at 45°c temperature by sustainable machine. Here in figure given the effect of denim garments fabric before and after wash.

Before wash After wash

Figure 3: Enzyme bleach Wash effect of sustainable machine



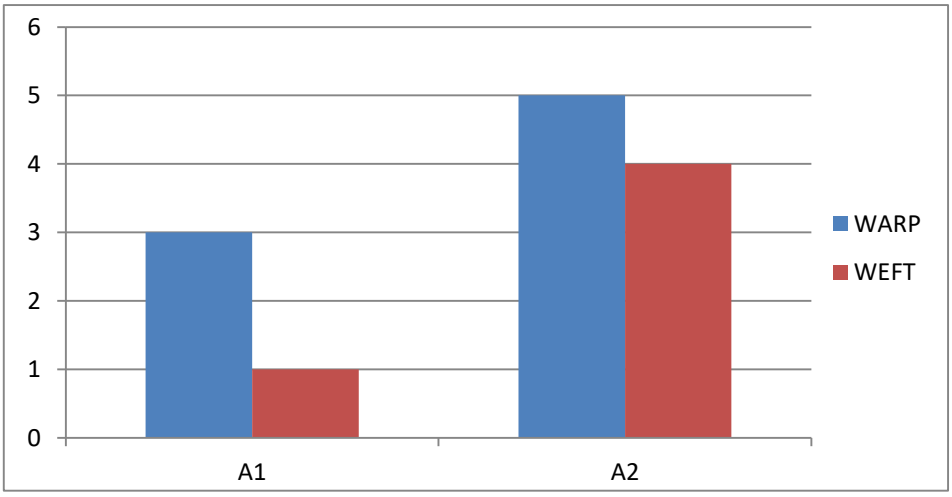

Graph 9: Tensile strength Chart

(A1- Before Wash, A2 - Sustainable Enzyme Wash, A3 - Sustainable Enzyme Bleach Wash) .

Figure shows: tensile strength in warp and weft direction of sample is good in sustainable enzyme wash.

Table 13: Rubbing Test Result

| Testing Process | Dry | Wet |
|---|---|---|
| Sustainable Enzyme Wash | 3- 4 | 1 – 2 |
| Sustainable Enzyme Bleach Wash | 4 - 5 | 3 – 4 |




Graph 10: Rubbing Test Chart

(A1 - Sustainable Enzyme Wash, A2 - Sustainable Enzyme Bleach Wash)

Figure shows color fastness to rubbing of enzyme wash was poor but in bleach wash color fastness to rubbing was good in sustainable process.

## Conclusion

Increasing environment problems have urged companies manufacturing goods to meet basic necessities of people to turn their looks to environment based Managements strategies. This new approach also forms the basis of sustainable production. The main objective of sustainable production is to adopt and implement certain strategies that can make maximum use of nature without upsetting the ecological balance. This project work was done for looking the best op-

tion for enzyme wash and bleach wash from sustainable wash. It was indicated that color fastness to rubbing of enzyme wash was poor but good at tensile strength .Enzyme bleach wash by sustainable process made the greatest influence on change in the properties of sample like color fastness to rubbing was good and a little bit lesser tensile. Sustainable wash is good for environmental and time context. So, if we can be able to get fewer better enzyme effect from sustainable wash anyway than it will be great for both our apparel and environment sector.

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