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A comparative study of enzyme (Bio-Polishing) pretreatment with singeing on cotton woven fabric

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Abstract:*Textile processing is a growing industry that traditionally has used a lot of water, energy and harsh chemicals. Bio-polishing is a developing and promising method for lowering the consumption of chemicals specially in wet finishing where plenty of these compounds are used. The singeing process replaced with environment-friendly approach using enzymes. Enzymes are specific and fast in action and small amounts of enzyme often save largeamounts of energy and costing. In this study, we had done bio-polishing treatment in samples of Cotton Woven fabrics by enzyme. For this experiment I have performed the combined scouring & bleaching to remove sizing material from woven fabric. Then the fabricswere treated with enzyme. On the other hand, I had collected the fabric from the factory that was from before singeing and after singeing. Before that I also collected the fabric only scouring was done but not bleaching, because of our working benefit.*

Keywords:*Bio-polishing, Cotton woven fabric, Singeing, Eco-friendly, Cost saving.*

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I. Introduction

Textile is rapidly gaining wider recognition because of their non-toxic and eco-friendlycharacteristics and with the increasingly important requirement for textile industries to reduce pollution in textile production, the use of enzymes in the chemical processing of fibers. Enzymes were discovered in the second half of the nineteenth century, and since are routinely used in many environmentally friendly and economic industrial sectors. There is increasing demand to replace some traditional chemical processes with biotechnological processesinvolving microorganisms and pectinases enzyme. [1]

Singeing is an important pre-treatment operation in the processing of cotton and cotton blended Woven fabric. The mainobjective of singeing is to remove the projecting fiber which makes the hairiness on fabric surface. Enzymes is another in textile wet processing has added a new line research and likely eco-friendly substance to give a good solution to remove hairiness from knitted fabric without burn effect on fabric. [2]

1.1 Singeing

The verb ‘singe’ literally means ‘to burn superficially’. Technically, singeing refers to theburning-off loose fibers not firmly bound into the yarn and/or fabric structure. Singeing isan important part of pretreatment. This is the burning off of protruding fiber ends from thesurface of the fabric. If not done properly, unclear print patterns, mottled fabric surfaces,and pilling results.

- Loose yarns not firmly bound into the fabric structure;
- Protruding fiber ends sticking out of the textile yarns and/or fabrics.

Textiles materials are most commonly singed in woven or knitted fabric form or in yarn form. [3]

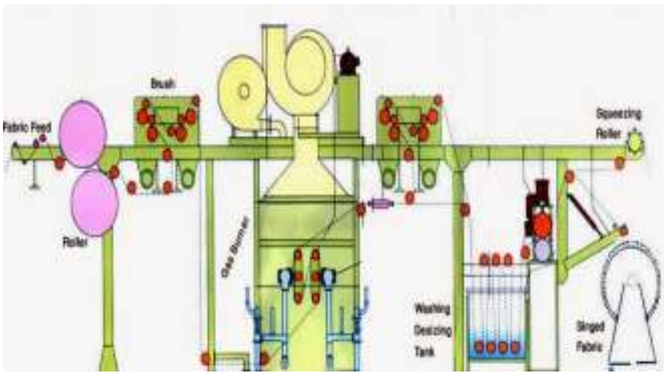

Fig.-1: schematic diagram of singeing machine

1.2 Enzyme Treatment (Bio-polishing)

The bio-polishing process targets the removal of the small fiber ends protruding from the yarn surface and thereby reduces the hairiness or fuzz of the fabrics. The hydrolysis action of the enzyme weakens the protruding fibers to the extent that a small physical abrasion force is sufficient to break and remove them. Bio polishing can be accomplished at any time during wet processing but is most convenient performed after bleaching. It can be done in both continuous or batch processes. However, continuous processes require some incubation time for enzymatic degradation to take place. Removing the fuzz makes thecolor brighter, the fabric texture more obvious, and reduces pilling. Unfortunately, the treatment also reduces the fabric strength. Smoother yarns also increase the fabric softness, appearance and feel. Since it is an additional process, the bio-polished garments may cost slightly more. Next time you buy apparel, look for the label "Bio-Polished. [4]

1.3 Structure of cotton

Cotton, the seed hair of plants of the genus Gossypium, is the purest form of cellulose readily available in nature. It has many desirable fibre properties making it an important fiber for textile applications. Cotton is the most important of the raw materials for the textile industry.The cotton fibers is a single biological cell with a multilayer structure The layers in the cell structure are, from the outside of the fiber to the inside, cuticle, primary wall, secondary wall, and lumen. These layers are different structurally and chemically [6].The primary and secondary walls have different degrees of crystalline, as well asdifferent molecular chain orientations. The cuticle, composed of wax, proteins and pectins is2.5% of the fiber weight and is amorphous. The primary wall is 2.5% of the fiber weight, has a crystalline index of 30%, index of 70%, and is composed of cellulose. The lumen is composed of protoplasmic residues [6]. Cotton fibers' have a fibrillar structure. The whole cotton fiber contains 88 to96.5% of cellulose, the rest are non cellulosicpolysaccharides constituting up to 10% of the total fiber weight [7]. The primary wall in mature fibres is only 0.5-1 µm thick and contains about 50% of cellulose. No cellulosic constituents consist of pectins, fats and waxes, proteins and natural colorants. The secondary wall, containing about 92-95% cellulose, is built of concentric layers with alternatic shaped twists. The layers consist of densely packedelementary fibrils, organized into microfibrils and macrofibrils. They are held together by strong hydrogen bonds. The lumen forms the centre of the fibers. Cotton is composed almost entirely of the polysaccharide cellulose. Cotton cellulose consists of crystalline fibrils varying in complexity and length and connected by less organized amorphous regions with anaverage ratio of about two-thirds crystalline and one-third non crystalline material, depending on the method of determination [8].The chemical composition of cellulose is simple, consisting of an hydroglucose units joined by β-1,4-glucosidic bonds to form linear polymeric chains [9] .The individual chainsadhere to each other along their lengths by hydrogen bonding and Van der Waals forces. The physical properties of the cotton fiber as a textile material, as well as its chemical behavior and reactivity, are determined by arrangements of the cellulose molecules with respect toeach other and to the fiber axis. The primary wall is about 1 µm thick and comprises onlyabout 1% of the total thickness of cotton fiber. The major portion of the non cellulosicconstituents of cotton fiber is present in or near the primary wall. Non cellulosic impurities,such as fats, waxes, proteins, pectins, natural colorants, minerals and water-solublecompounds found to a large extent in the cellulose matrix of the primary wall and to a lesserextent in the secondary wall strongly limit the water absorbency and whiteness of the cottonfiber. Pectin is located mostly in the primary wall of the fibre. It is composed of a highproportion of D- galacturonic acid residues, joined together by α(1→4)-linkages. Thecarboxylic acid groups of some of the galacturonic acid residues are partly esterified withmethanol. Pectic molecule can be called a block-copolymer with alternating the esterified andthe non- esterified blocks. In the primary cell wall pectin is covalently linked to cellulose orin other plants to hemi cellulose, or that is strongly hydrogen-bonded to other components.Pectin is like powerfulbiological glue. The mostly water-insoluble pectin salts serve to bindthe waxes and proteins together to form the fiber's protective barrier.

II. Experimental Works

2.1Materials

In the experiment, I have used a Substrate of 100% grey cotton woven fabric which was received from MOMTEX (Pakiza Textile). I used SodiumHydroxide (NaOH) for scouring process & Detergent, Sequestering Agent, Wetting Agent/Non-ionic surfactants chemical are use. For fabric testing, we have to needed Instruments of Multi fiber Apparatus, Weight balance**.**

2.2 Material Preparation

A Cotton woven fabric was kindly provided from MOMTEX (Pakiza Textile)whichconsists of dirt, dust, oil, wax etc. We have taken samples from it each weighing 10 grams. Before the scouring & bleaching treatment the substrate was washed in distilled water to extract the water soluble constituents and then dried in laboratory oven dryer. After washing and drying the oven dry weight of the samples was measured in an electric balance.

2.3 Methods

2.3.1Combined scouring & bleaching process

The fabrics was combined scoured and bleached by using 5% stock solution of Wetting Agent, NaOH , Sequestering Agent and Hydrogen peroxide. It was carried out for 40 minutes at 95°C at a liquor ratio of 1:20

2.3.1.1 Recipe

OMEX (Sequestering agent): 1 gm/l
KNN (Wetting agent): 1 gm/l
Caustic soda: 2 gm/l
Hydrogen peroxide: 4 gm/l
Fabric wt: 10 gm
Liquor Ratio: 1:20
Temp: 95℃
Time: 40 min
Total Liquor: 10×20= 200 ml

2.3.2 Bio polishing process

After completing combined scouring and bleaching process the fabric was bio polished with the help of acetic enzyme. 5% stock solution of Acetic enzyme, acetic acid, sequestering agent, wetting agent are used to do this process in presence of pH-5.5 at 55°C & 40 minutes & liquor ratio was 1:20. The hydrolysis action of the enzyme weakens the protruding fibers to the extent that a small physical abrasion force is sufficient to break and remove them.

2.3.2.1 Standard Recipe for Bio-polishing

Concentration of Enzyme = 3%
M : L = 1:10
Temperature = 55ºC
Time = 55 minutes
pH = 4 – 5

2.3.2.2 Process Variables

To achieve optimum bio-polishing, the process variables have been varied as mentioned below-
Concentration: Concentration of enzyme0.5%, 1%, 2%, 2.5%, 3% & 4%.
Temperature: Temperatures are 40 0C, 45 0C, 50 0C, 55 0C & 60 0C.
pH: 3 - 4, 4 - 5 & 5 - 6.
M: L: 1:5, 1:10, 1:15 & 1:20.
Mechanical Agitation: Vigorous Stirring, Medium Stirring & Without Stirring.

2.3.3 Calculation

Sequestering agent = $\frac{200*1*100}{1000*5}$= 4 ml

Wetting agent =$\frac{200*1*100}{1000*5}$ = 4 ml

Acetic enzyme = $\frac{200*3*100}{1000*5}$ = 12 ml

Acetic acid = $\frac{200*1*100}{1000*5}$ = 4 ml

Required amount of water:
= 200 ml – (4+4+12+4) ml
= 176 ml

2.3.4Physical Materials and Machineries

- PH Paper
- Dyeing Pot
- Pipet
- Conical Flax
- Volumetric flax
- Stirrer
- Water (Distil)

- Woven Fabric
- Dyeing m/c
- Weight balance
- Dryer
- Hairiness tester

III. Result and Discussion

3.1 Assessment of Hairiness

Assessment of Grey fabric-
After the assessment under grey scale we got rating for grey fabric is 4.
Assessment of fabric after singeing-
After the assessment under grey scale we got rating for grey fabric is 4-5.
Assessment of fabric after Bio-polishing-
After the assessment under grey scale we got rating for grey fabric is 4-5.
From the assessment under grey scale using oblique lighting we got equal result for bothsingeing and Bio-polishing. It means values are not concern for the fabric quality.

3.2 Percentage of weight loss:

Weight loss after Singeing-
Weight of fabric at grey stage is 1.58 g
Weight of fabric after singeing is 1.442 g
Wt. loss of the sample=

$$\frac{\text{Wt. of the sample before experiment} - \text{Wt. of the sample after experiment}}{\text{Wt. of the sample before experiment}} X100$$

$= \frac{1.58-1.442}{1.58}$ X100

= 8.734%
Weight loss after Bio-polishing-
Weight of fabric at grey stage is 10 g
Weight of fabric after Enzyme is 9.351 g
Wt. loss of the sample=

$$\frac{\text{Wt. of the sample before experiment} - \text{Wt. of the sample after experiment}}{\text{Wt. of the sample before experiment}} X100$$

$= \frac{10-9.351}{10}$ X100

= 6.49 %
In case of weight loss calculation we got better result after bio-polishing.

Fig.-2:fabric at grey stage

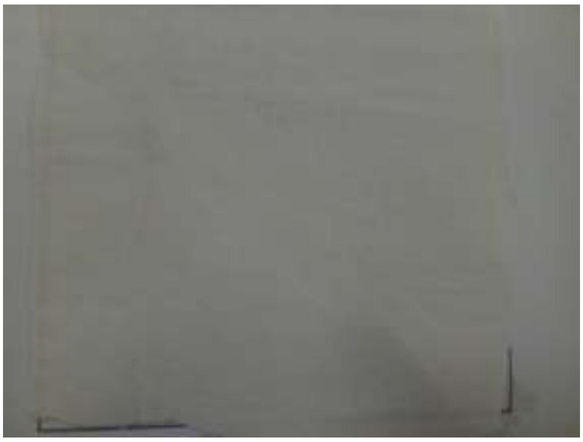

Fig.-3:fabric after scouring & bleaching

Fig.-4:fabric after Enzyme

Fig.-5:fabric after singeing

IV. Conclusion

After completing my experiment and assessment I have found that, bio-polishing treatment on woven fabric is better than Singeing treatment. As per the hairiness assessment and weight loss calculation it is partially assure that Bio-polishing can be effective for wovenfabric. There might be some limitations of the research like all the experiments are done in the lab not apply for bulk production, chemicals might be contained impurities, Assessment of hairiness was done in basis of visual analysis by means of grey scale. In today's textile world the main objectives of every company is making their product cost effective by holding the required quality. I have tried to do something like that. If this experiment becomes fruitful for bulk production, it can reduce cost. I faced some limitation during our experiment; if this lacking can be overcome this experiment can be more fruitful. As our country is running out of natural resources like gas, so it will be more difficult to run singeing process in future. So I have tried to reduced this gas uses by replacing singeing process with bio-polishing.

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