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# Bleach Washing Combined with Pumice Stone for the Modification of Denim Garments

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**ABSTRACT**

Washing of Denim garment with pumic stone combined with bleaching powder was investigated to preserve the quality and to create more distress worn-look fashionable Denim garment. For this, regular Denim trouser (twill 3/1 weave, composition 100 % cotton) was selected for the present investigation. The Denim trouser has been processed by stone-bleach washing technique, using various concentrations of pumice stone (10 to 70%) (owg) with 10 g/L bleaching powder at 40 $^{o}$C for 20 min. In order to evaluate the influence of pumice stone on physico-mechanical properties like tensile strength, elongation at break, fabric weight, colour change, the dimensional characteristics (shrinkage/ extensibility), stiffness and water absorption has been determined. Fabric surface was also examined by scanning electron microscope (SEM). It can be concluded that pumice stone made the influence on Denim properties, whereas in producing durable and distressed worn look Denim garment the optimised washing condition for the best value is determined.

**Key words***:* pumice stone, Denim garment, bleaching powder, colour shade.

## INTRODUCTION

There is huge demand of Denim garments with distressed worn look. Various types of washing have been used on completely sewn Denim ready-made garments to give distressed Denim look and have the largest effect on finished garment (Khan *et al.,* 2012a). Stone washing is one of such wash type used purposely for Denim. In stone-washing the Denim garment is washed along with pumice stone in industrial washing machine. Denim is basically cotton and very stiff fabric and the warp yarns are dyed with indigo which remains on surface (Razzak, 2004; Grieve *et al.,* 2006; Kashem, 2008; Islam, 2010). During washing they are spun together in the washing machine and lighter the colour of the garment and produce better contrasts distressed look. To minimise the unwanted tear and wear of the garment, the amount of pumice stone, temperature and time of washing is to be set perfectly and controlled in washing process. The Denim with pumice stone alone could cause wear and tear of the garment and time consuming. To overcome excessive damage, stone-washing of

Denim is carried out with the aid of bleaching powder. In this washing process, bleaching powder is used combined with pumice stone to provide distressed worn out look to the Denim garment. Many researchers have been investigated in the past on enzyme and bleach washing for Denim (Wood, 1991 and 1992; Morries, 1994; Kang, 1998; Heikinheimo, 2000; Khan *et al.,* (2012a, 2012b); Sangita et al, 2010). However, stone-wash on Denim is very popular of today's youth with specific washing effects and sufficient literatures of Denim garment washing with stone-bleach wash has not been available yet.

The major objective of this study is to examine the effect of various amounts of pumice stone in bleach washing with a fixed amount of bleaching powder, temperature and time. It is believed that if the Denim garment is modified using bleaching powder combined with pumice stone in order to decrease the loss of minimum strength, so that their attack would be restricted only to the surface of the fabric, then the durability of the garment will be increased and achieved required colour fading. Therefore, in the present investigation attempts have been taken to wash Denim garments with pumice stone combined with bleaching powder to produce today's most preferred fashionable Denim designs.

## MATERIAL AND METHODS

### Materials

The Denim fabric used in this investigation was of 100% cotton twill weave (3/1 LHT & 381 g/$m^2$), construction 70 × 42 / 10 × 9, indigo dyed Denim, manufactured in a Textile mill in Bangladesh. Denim garments (trousers) were manufactured using the stated Denim fabric.

A bleaching powder (Bleach KCI, India) (35% available chlorine) was used for washing Denim garments. In addition, soda ash ($Na_2CO_3$, China) was used as buffer to control pH of the washing medium. Detergent (Hostapur WCTH, BASF, Germany); desizing agent (Luzyme FR-HP, BASF, Germany); anti-backstaining (Antistain-LP30, GDS, India), acetic acid (China), softener (Text-soft, BASF, Germany) and fresh pumice stones (Turkey) of medium size (4-5 cm) were used for the experiment.

### Methods

### Desizing treatment

The desizing was conducted in liquor containing 0.6 g/L detergent (Hostapur WCTH), 1.2 g/L desizing agent (Luzyme FR-HP), anti-back staining agent (Antistain-LP30) and material to liquor ratio of 1:10 in an industrial horizontal sample washing machine (Ngai Shing, model-NS 2205, Hong Kong) at temperature 60°C for 20 min. as pre-treatment in order to remove the size materials of warp yarns which was applied in fabric manufacturing for reducing yarn breakage. After that washed with hot water at 70°C followed by cold water (25°C) wash.

### Stone-bleach treatments

Desized Denim trousers were treated with stones and bleaching powder in the same sample washing machine at different concentrations of pumice stone (10-70%) with fixed temperature and time followed by the standard washing procedure (Hams, 2009). All treatments were involved in the rotary cylindrical sample washing machine at 30 rpm. The pumice stone treatment was conducted combined with (i) 10 g/L bleaching powder (Bleach KCI) in liquor containing 5 g/L soda ash keep the pH at 10.5; (ii) 10 g/L bleaching powder (Bleach KCI) in liquor containing without soda ash at pH 9.0 and at 40°C for 20 min for both cases.

### Hydro-extracting and drying processes

Stone-bleach treated Denim trousers were squeezed in a laboratory scale hydro-extractor machine (Zanussi, England) to remove excess water from the garments at 200 rpm for 4 min. Then dried in a steam drier (Opti-Dry, Roaches, England) at 75°C for 40 min. Treated Denim garments were then evaluated in testing machines and characterised of their physical and mechanical properties to assess product performance.

### Characterising the treated Denim garment

Treated all Denim trousers were conditioned at 65% RH and at 20°C for 24 h before testing according to ASTM D1776. Tensile strength and elongation at break was determined by the US Standard Grab test method according to ASTM D 5034. Weight loss (%) in fabric was calculated from the difference in fabric weight (GSM) before and after the treatment according to ASTM D 3776.

Dimensional changes (shrinkage/extension, %) was calculated from the difference in fabric length before and after washed garment according to AATCC test method 96. Stiffness was measured from the bending stiffness in fabric by Shirley stiffness tester according to BS 3356. Water absorption of the garment was measured from the differences in rate of uptake according to BS 3449. Changes in the original colour shade of the fabric was rated using Grey scale for colour change according to AATCC evaluation procedure 1. Scanning electron microscopy was studied using SEM (Hitachi, model-S 3400 N, Japan).

## RESULTS AND DISCUSSION

Denim garments were subjected to treatment with the pumice stone combined with bleaching powder and some physical-mechanical tests were performed to evaluate changes or improvements in Denim garment. The surface appearances of the untreated/modified Denim garments were also studied.

### Effects of pumice stone concentration

In this study, mechanical abrasion was achieved by pumice stone in the washing machine.

**Table 1: Effect of pumice stone-bleach washing on the tensile strength of denim garment in warp and weft directions**

| Pumice stone (%) | Loss in tensile strength in warp direction, (%) | | Loss in tensile strength in weft direction, (%) | |
|---|---|---|---|---|
| | Bleaching with soda ash | Bleaching without soda ash | Bleaching with soda ash | Bleaching without soda ash |
| 0.0 | 0 | 0 | 0 | 0 |
| 10 | 11.78 | 19.91 | 6.61 | 9.56 |
| 20 | 13.41 | 20.32 | 7.35 | 10.29 |
| 30 | 15.04 | 21.14 | 8.09 | 11.76 |
| 40 | 17.48 | 21.95 | 9.56 | 12.50 |
| 50 | 20.32 | 24.80 | 10.29 | 13.97 |
| 60 | 21.13 | 26.01 | 11.03 | 14.70 |
| 70 | 22.76 | 27.64 | 11.03 | 14.70 |

**Table 2: Effect of pumice stone-bleach washing on the elongation at break of denim garment in warp and weft directions**

| Pumice stone (%) | Elongation at break in warp direction, (%) | | Elongation at break in weft direction, (%) | |
|---|---|---|---|---|
| | Bleaching with soda ash | Bleaching without soda ash | Bleaching with soda ash | Bleaching without soda ash |
| 0.0 | 0 | 0 | 0 | 0 |
| 10 | 18.45 | 12.25 | 4.31 | 3.59 |
| 20 | 17.90 | 11.57 | 3.73 | 2.59 |
| 30 | 17.08 | 9.64 | 3.61 | 2.01 |
| 40 | 16.80 | 8.81 | 2.87 | 2.01 |
| 50 | 16.39 | 8.26 | 2.30 | 2.01 |
| 60 | 15.70 | 7.71 | 2.01 | 1.30 |
| 70 | 15.42 | 7.43 | 2.01 | 1.30 |

**Table 4: Effect of pumice stone-bleach washing on the dimensional changes (shrinkage and extension) of denim garment in warp and weft directions**

| Pumice stone | Shrinkage in warp direction, (%) | | Extension in weft direction, (%) | |
|---|---|---|---|---|
| (%) | Bleaching with soda ash | Bleaching without soda ash | Bleaching with soda ash | Bleaching without soda ash |
| 0.0 | 0 | 0 | 0 | 0 |
| 10 | 5.0 | 7.0 | 0 | 0.5 |
| 20 | 6.0 | 7.0 | 0.5 | 0.5 |
| 30 | 6.0 | 7.0 | 1.0 | 1.0 |
| 40 | 6.0 | 7.0 | 1.0 | 1.0 |
| 50 | 7.0 | 8.0 | 1.0 | 1.0 |
| 60 | 8.0 | 8.0 | 1.0 | 2.0 |
| 70 | 8.0 | 8.0 | 1.0 | 2.0 |

**Table 5: Effect of pumice stone-bleach washing on the stiffness of denim garment in warp and weft directions**

| Pumice stone | Loss in stiffness in warp direction, (%) | | Loss in stiffness in weft direction, (%) | |
|---|---|---|---|---|
| (%) | Bleaching with soda ash | Bleaching without soda ash | Bleaching with soda ash | Bleaching without soda ash |
| 0.0 | 0 | 0 | 0 | 0 |
| 10 | 28.89 | 22.22 | 6.2 | 3.1 |
| 20 | 31.11 | 22.22 | 6.2 | 6.2 |
| 30 | 31.11 | 24.44 | 9.4 | 6.2 |
| 40 | 33.33 | 24.44 | 12.5 | 6.2 |
| 50 | 33.33 | 26.67 | 12.5 | 9.37 |
| 60 | 35.55 | 28.89 | 12.5 | 9.37 |
| 70 | 35.55 | 28.89 | 12.5 | 9.37 |

**Table 3: Effect of pumice stone-bleach washing on the fabric weight and colour shade of denim garment**

| Pumice stone | Fabric weight loss, (%) | | Colour shade loss, (%) | |
|---|---|---|---|---|
| (%) | Bleaching with soda ash | Bleaching without soda ash | Bleaching with soda ash | Bleaching without soda ash |
| 0.0 | 0 | 0 | 0 | 0 |
| 10 | 3.41 | 4.99 | 40 | 60 |
| 20 | 3.94 | 5.51 | 50 | 60 |
| 30 | 4.99 | 6.04 | 50 | 60 |
| 40 | 5.51 | 7.61 | 70 | 70 |
| 50 | 5.51 | 8.13 | 70 | 80 |
| 60 | 6.03 | 9.45 | 80 | 80 |
| 70 | 6.03 | 9.45 | 80 | 80 |

The addition of pumice stone in bleach washing with bleaching powder accelerates more mechanical abrasion and allowing degradation on both surface colour and fibre polymer-chain quicker which affects on the fabric properties. The effect of pumice stone with various concentrations (10-70%) (owg) on the properties of Denim garments was determined and is shown in Tables 1- 6.

The tensile strength evolution after stone-bleach washing with soda ash and without soda ash can be seen in Table 1. On washing at various concentrations of pumice stones the tensile strength decreased due to the rubbing action provided by the pumice stones. As a result, warp yarns are more affected by stone than weft in the both cases due to the weaving character of warp faced twill fabric. Again the warp yarns are dyed with indigo which remains on yarn surface and by the rubbing action of pumice stone the warp yarn surface is more affected than weft yarn. It can be seen from Table 1 that, at low concentration (10%) of pumice stone, 19.91% strength loss was observed in warp direction when the garments were treated without soda ash, and 11.78% strength loss was observed in the case of with soda ash in washing, and with higher pumice stone concentrations (up to70%), the strength losses were higher, and these were 27.64% and 22.76% respectively. Thus fibre degradation is more at low alkaline medium (without soda ash) than higher alkaline medium (with soda ash) during stone-bleach washing. Again, it can be seen from Table 2 that, at low concentration (10%) of pumice stone, higher elongation at break was observed, but with higher pumice stone concentrations (20-70%), elongation decreased in both washing with and without soda ash. Due to more rubbing, fibres are damaged and more weaken with higher pumice stone concentrations, as a result, elongation decreased. The stone-bleach washing with soda ash caused 18.45% elongation at low concentration of pumice stone (10%) and 15.42% elongation at higher concentration of pumice stone (70%), compared to untreated Denim; and 12.25% and 7.43% elongation, respectively for the case of without soda ash in washing.

Table 3 shows the impact of pumice stone on the weight loss of Denim garments. Treatments showed that high weight loss (9.45%) was obtained in washing with 60% pumice stone concentration compared to the weight (6.03%) in washing with soda ash.It can also be seen from the Table 3 that the colour shade decreased less when the fabrics were treated with soda ash than without soda ash with increased pumice stone concentrations. More than 30% pumic stone in bleach wash, the colour shade is not acceptable in textiles. Table 4 shows that the dimensional stability loss (shrinkage) by pumice stone washing with soda ash and without soda ash was found up to 8.0% in warp direction, whereas extension in weft occurred up to 1.0%, and 2% respectively. During fabric manufacturing warp yarns are always in tension. In washing, due to relaxation (Cookson, 1992), warp way shrinkage is more than weft.

Table 5 shows the loss of stiffness in pumice stone washing combined with bleaching powder. It can be seen from the Table 5 that pumice stone with soda ash caused 29-36% stiffness loss and without soda ash 22-29% loss. The stiffness loss is higher in pumic stone washing with soda ash than without soda ash. Table 6 shows the effect of pumice stone concentration on water absorption. From the Table 6 it can be seen that the water absorption is increased when washing was performed by pumice stone with soda ash and without soda ash due to the loosening of surface fibres by the abrasion of pumice stones. The water absorption increased 14-18% at 10-50% concentration of pumice stones for with soda ash and 9-13% without soda ash. Washing with more than 40% pumic stone concentration does not have any more effect on water absorption.

**Table 6: Effect of pumice stone-bleach washing on the water absorption of denim garment**

| Pumice stone(%) | Water absorption, (%) | |
|---|---|---|
| | Bleaching with soda ash | Bleaching without soda ash |
| 0.0 | 0 | 0 |
| 10 | 14.28 | 9.52 |
| 20 | 15.08 | 11.11 |
| 30 | 15.87 | 12.70 |
| 40 | 16.87 | 12.70 |
| 50 | 17.46 | 12.70 |
| 60 | 17.46 | 12.70 |
| 70 | 17.46 | 12.70 |

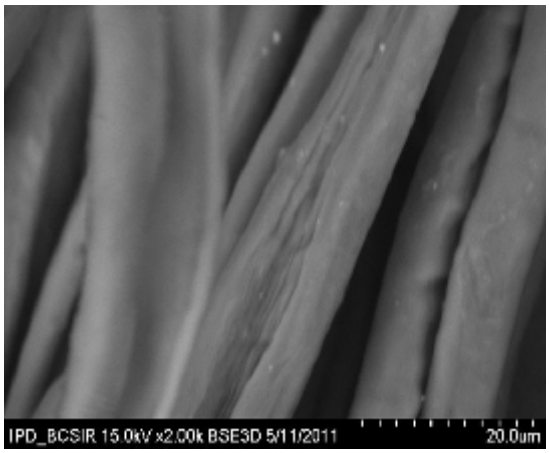


**Fig. 1: SEM of untreated denim sample**

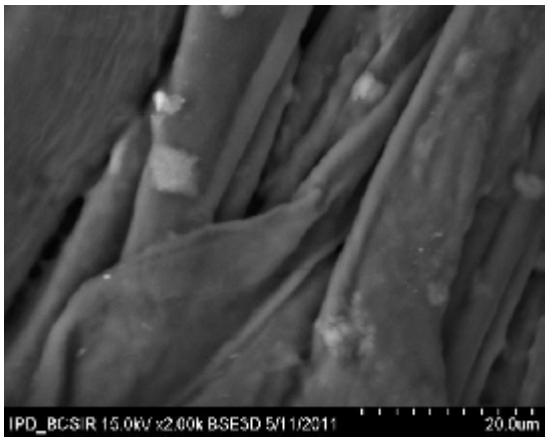


**Fig. 2: SEM of stone -bleach treated denim sample**

**Scanning electron micrograph**

The morphological value of the Denim garments were examined by scanning electron microscope (SEM). Figure 1 shows SEM images of untreated Denim garment. It is clear from the image that the parallel ridges and no ruptures were visible, because yarns are coated with sizing materials. Figure 2 shows SEM images of stone-bleach treated Denim garment. Loosened fibre and more cracks were observed on the surface of fibres due to the effect of stone in bleach washing for Denim.

## CONCLUSIONS

The physical-mechanical properties of the Denim garments are influenced by the washing with pumice stone. Pumice stone-bleach washing with bleaching powder gives a used look appearance on Denim garment distinctly and produced fashion garment. The warp yarns with indigo dyeing are affected its surface colour markedly and are more weakened than the weft yarns by the rubbing action of pumice stone in washing. This study showed that stone-bleach washing without soda ash caused more colour loss and had a more negative effect on tensile strength, whereas washing with soda ash caused more stiffness loss and more water absorption and less strength loss. Examination of the stone-bleach treated garments by SEM shows more crack on the fibre surface. It is further noted that pre-washed Denim samples are almost stiff and harder than the stone-bleach treated Denim ready-made garments. It is concluded that decrease in tensile strength was higher in stone-bleach washing containing without soda ash than with soda ash and the use of 30% pumice stone in bleach washing with soda ash is the best value compared to all the fabric properties.

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## REFERENCES

1. Cookson, P. G., Relationships Between Hygral Expansion, Relaxation Shrinkage, and Extensibility in Woven Wool Fabrics, *Textile Res. J.* **62:** 44-51 (1992).

2. Grieve, M., Biermann, T. and Schaub, K., The use of indigo derivatives to dye Denim material, *Science & Justice*, **46:** 15-24 (2006).

3. Hams Group, personal communication, Hams Washing & Dyeing Limited, 190 Tejgaon I/A, Dhaka, Bangladesh, (2009).
4. Heikinheimo, L., Buchert, J., & Suominen, P., Treating Denim Fabrics with Trichoderma Reesei Cellulases, *Textile Res. J.* **70** (11), 969-973 (2000).
5. Islam, M. T., *Garments Washing & Dyeing,* Ananto Publications, Dhaka, pp. 220-222 (2010).
6. Kang, I., Yang, C., Wei, W., & Lickfield, G. C., Mechanical Strength of Durable Press Finished Cotton Fabrics, Part 1: Effects of Acid Degradation and Cross Linking of Cellulose by Polycarboxylic Acids, *Textile Res. J.*, **68**: 856-870 (1998).
7. Kashem, M. A., Garments Merchandising, 1st edn., Lucky-One Traders, Dhaka, Bangladesh, Pp. 69-71 (2008).
8. Khan, M. M. R., Mondal, M. I. H., Alam, A. B. M. F. and Hossain, M. H., Modification of Denim Garment with the Treatment of Bleaching Powder, *Can. J. on Chemical Engineering & Technology*, **3(2)**: pp. 30-36 (2012a).
9. Khan, M. M. R., Mondal, M. I. H. and Uddin, M. Z., Sustainable Washing for Denim Garments by Enzymatic Treatment, Journal. of Chemical Engineering, The Institution of Engineers (IEB), ChE 27(1): 27- 31 (2012b).
10. J.O. Otutu, E. Osabohien and E.M. Efurhievwe. *Orient. J. Chem*. **26**(1): 31-38 (2010).
11. Morries, C. E., & Harper, R. J., Comprehensive View on Garment Dyeing and Finishing, *American Dyestuff Reporter*, **83**: 132-136 (1994).
12. Razzaque, M. A., Garment & Textile Merchandising, 1st ed. Popular Publications, Dhaka, pp. 223-226 (2004).
13. Sangita, S., Kumar, P. S. and Chandran, M. R., Types of Stone Wash & Their Effects on the Denim Fabric, *The Indian Textile Journal*, (2010).
13. Wood, T. M., Fungal Cellulases, Biosynthesis and Biodegradation of Cellulose. P. J. Weimer, Haigler, Candace H., Marcel Dekker, New York, pp. 491-533 (1991).
14. Wood, T. M., Fungal Cellulases. *Biochem. Soc. Transact*., **20**: 46-52 (1992).