Enhancement in the properties of jute-cotton union fabrics through wet processing treatments: Part I—Simple woven structures with jute weft in subdued form

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In this study, plain and warp rib woven fabrics with cotton warp and jute weft have been produced in such a way that appearance of jute weft is subdued on fabric surface. The fabrics are then subjected to four kinds of wet processing treatments viz. bleaching with hydrogen peroxide followed by peracetic acid termed as sequential bleaching, woollenisation, chemical softening and bio softening followed by chemical softening to suppress harshness and prickliness of jute component and to enhance fabric properties. Improvement in fabric properties is determined through objective and subjective evaluation. All the treatments improve the fabric handle as measured through the reduction in bending length and drape coefficient. Among all the treatments sequential belching is found to be the best so far as improvement in feel of the fabric is concerned.

Keywords: Fabric handle, Jute-cotton union fabric, Subdued form, Union fabric, Wet processing, Woven structure

1 Introduction

Jute¹ has dominant position for packing purpose for a very long period. However, after introduction of light weight synthetic products which provided a substitution for jute, use of jute started declining drastically. Due to this, survival of jute growers and related industries was put to threat. In order to revamp jute industry, Government of India reserved the packing of traditional commodities like sugar and food grains with jute material by proclaiming the mandatory jute packing by act (PJMA 1987) and also took steps to encourage research to promote jute consumption for other diversified uses.

Jute fibre is coarse, harsh in feel and prickles human skin which restricts its application areas. As a part of seeking diversified uses of jute, efforts have been made to spin jute blended yarns and study their properties²,³. However, production of jute blended yarns is tedious and requires special efforts in spinning². Various researchers worked in the areas of jute blended yarn and jute blended union fabrics to enhance its acceptability in wider section of textile application. The tailorability of jute blended suiting fabrics was found to be inferior with poor handle properties as reported in the literature⁴. Textile chemists made various efforts to improve aesthetic values of jute and jute blended textiles through chemical and biochemical treatments. Improvement in jute fabric handle and considerable reduction in surface hairs is reported by Chattopadhyay et al⁵. In another study they have reported⁶ improved whiteness and softness, achieved through environment friendly sequential peracetic acid-hydrogen peroxide bleaching of jute in comparison with the conventional hypochlorite-hydrogen peroxide bleaching.

In the present study, an attempt has been made to find a newer application of jute in jute-cotton union fabric for enhancement of its properties through chemical/biochemical pretreatments and finishing. Jute-cotton union fabrics are produced using cotton yarn as warp and jute yarn as weft. Weave and thread densities are so chosen to have subdued appearance of jute weft and dominant appearance of cotton warp on both sides of the fabric. Thus, fabric construction itself partially suppresses harsh feel and prickliness associated with jute on fabric surface. These fabrics are subjected to various wet processing treatments to improve their look and feel. In this study, we have tried to examine the effects of various treatments to soften the jute-cotton union fabric to enhance its acceptability. To avoid interfering effects of scouring treatment, it was kept common to all the softening treatments. The control sample in the study was therefore the scoured one.
2 Materials and Methods

2.1 Materials

2/10 Ne cotton warp yarn and 7 lbs jute weft yarn were used for the study.

Sodium carbonate, hydrogen peroxide, sodium metasilicate, peracetic acid, sodium hydroxide flakes, dilute acetic acid, polymeric quaternised softener (Lush Feel, Zydex industries, Vadodara, India) and acid cellulase enzyme (Palkostone, Maps Enzymes Limited, India) were used.

2.2 Methods

2.2.1 Weaving

From cotton cones acquired from the market, weaver’s beams were produced through warp preparatory processes of winding on PS-Mettler winding machine followed by sectional warping on P.Schweizer, Maschinebau sectional warping machine. Jute yarn was wound on pirns on Hatex pirn winding machine. Jute-cotton union fabrics were woven on a 36” power loom with dobby as well as drop box attachment of make Textile Cooper.

Samples were woven with 76 cm width in reed with plain and warp rib weaves using 36’s reed, 3 ends/dent. Picks/cm for plain and rib weaves were 6 and 12 respectively. Due to high cover factor of warp threads as compared to weft threads, warp appears dominantly on either side subduing weft appearance.

2.2.2 Wet Processing

The fabric was first scoured on jigger with 4% (owf) laboratory grade sodium carbonate at 80 °C, maintaining a material-to-liquor ratio of 1:30. After scouring the samples were divided into four parts. Each part was given one among the four treatments, as given below:

(i) Bleaching with hydrogen peroxide followed by peracetic acid (termed as sequential bleaching)
(ii) Woollenisation
(iii) Softening
(iv) Treatment with cellulase enzyme followed by softening.

The conditions of these treatments are given in Table 1.

2.3 Test Methods

2.3.1 Drape Coefficient and Stiffness

Drape coefficient of the fabric samples was measured as per IS: 8357-1977 method using drape meter [make Presto-Precision Standard Testing Equipment Corporation] with a circular test specimen of diameter 25 cm. An average of both the sides i.e. faces and back was taken for each sample.

Stiffness of the fabric samples in warp as well as weft direction was determined using cantilever test method as per ASTM D 1388-96 standards with a specimen size of 25 cm × 2.5 cm.

2.3.2 Tensile Strength

The tensile strength of the samples in warp as well as weft direction was measured as per the ASTM D 5034 method using CRE Paramount digi-strength tensile testing equipment. Test samples of 6 inch × 3 inch were used and the traverse speed was 375 mm/min. An average of 5 observations was taken for each sample.

2.3.3 Fabric-thickness, GSM and Threads/cm

Fabric thickness of the samples was measured as per the IS: 7702-1975 method using a precision thickness gauge with a flat anvil and a circular pressure foot. An average of 5 observations was taken for each sample.

GSM of the fabric samples was determined as per IS 1964-2001 method, for which circular sample of diameter 11.3 cm was cut using Paramount round cutter and weighed to calculate GSM.

Ends/cm and picks/cm were determined as per IS 1963-1981 method using a pick glass. An average of 5 observations was taken for each sample.

2.3.4 Relative Proportion of Jute and Cotton

To determine relative proportion of jute weft and cotton warp by weight at grey stage, a square grey

Table 1 — Wet processing treatment specification

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Sequential bleaching</th>
<th>Woolenisation</th>
<th>Chemical softening</th>
<th>Enzymatic+ Chemical softening</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>H₂O₂ (5% owf)</td>
<td>CH₃COOOH (5%)</td>
<td>NaOH (16%) (w/v)</td>
<td>Acetic cellulase enzymes (10%)</td>
</tr>
<tr>
<td>pH</td>
<td>11</td>
<td>6.5</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td>Time</td>
<td>2 h</td>
<td>1 h</td>
<td>45 min</td>
<td>1 h</td>
</tr>
<tr>
<td>Temperature</td>
<td>80-85°C</td>
<td>70°C</td>
<td>Room temp.</td>
<td>60°C</td>
</tr>
<tr>
<td>Material-to-liquor ratio</td>
<td>1:40</td>
<td>1:40</td>
<td>1:50</td>
<td>1:60</td>
</tr>
</tbody>
</table>


sample of 100 cm² was weighed. The ends and picks of the sample were unraveled carefully and weighed from which proportion of cotton warp and jute weft at grey stage was evaluated.

2.3.5 Subjective Evaluation of Fabrics

A panel of 36 respondents from various age groups, background and gender were selected for subjective evaluation of jute-cotton union fabrics. Respondents rated samples of five different weaves applied with same treatment with regard to general handle and softness. Rating was given mainly from two aspects, namely prickliness of the fabric in terms of general handle, and fabric softness. The rating range was 1-5, where 5 represents the best among all. Such rating was obtained for all processing treatments.

3 Results and Discussion

For each weave with its warp sett, maximum possible picks/cm on loom were accommodated. Warp and weft fractional covers, fabric thickness and jute content % depend on weave as shown in Table 2.

3.1 Effect of Sequential Bleaching on Fabric Properties

Table 3 shows the effect of sequential bleaching on bending length. It is observed that weft way bending length of the jute-cotton union fabric is reduced after sequential bleaching for rib weave and for plain woven fabric it is least affected. On the contrary, the warp way bending length is found to be increased. There are perhaps two phenomena playing simultaneously. One, reduction in stiffness due to partial removal of hemicellulose after bleaching and the other one is the introduction of some stiffness due to shrinkage of the fabric. The results show that first factor is predominated over the second in case of weft-wise direction while the reverse occurs in case of warp direction.

Bending length is also influenced by shrinkage due to wet processing which increases fabric GSM. A new parameter bending length/GSM is, therefore, taken to include the effect of such shrinkage on bending length for better interpretation of the results. Figure 1(a) shows the change in this parameter for sequential bleaching treatment weft way. It can be observed that weft way bending length/GSM on sequential bleaching is increased for plain weave, whereas it is least affected for rib weave.

Drape coefficient is also related to fabric feel and handle. Table 3 shows that after sequential bleaching, drape coefficient reduces for both the weaves which indicates an improvement in fabric feel and handle. Drop in drape coefficient may be attributed to partial removal of hemicelluloses from the jute component during alkaline bleaching.

To take into account of the influence of shrinkage due to wet processing treatments which increases the GSM and might affect the drape coefficient, a new parameter drape coefficient/GSM is taken for better interpretation of the results. It can be observed from Fig. 1(b) that drape coefficient/GSM increases for...
both the weaves on sequential bleaching which may be due to predominant effect of increase in GSM over improvement in softness due to sequential bleaching.

Table 3 also shows that tensile strength for both the weaves is reduced in both directions of the fabric samples due to sequential bleaching. Figure 1(c) shows the effect of sequential bleaching on weft way tensile strength/GSM. It can be observed that there is reduction in weft way tensile strength/GSM on sequential bleaching for both the weaves.

3.2 Effect of Woollenisation on Fabric Properties

Jute-cotton union fabric was given woollenisation treatment. This treatment gives wool like crimpiness to the jute. Table 4 shows that weft way bending length is decreased on woollenisation for both the weaves which indicates an improvement in fabric softness. During woollenisation treatment the woody stiffness imparting on hemicellulose part is partially removed which may have brought an improvement in the feel of the fabric, as observed from the drop in bending length. Table 4 also shows that warp way bending length is increased for plain weave and decreased for rib weave, whereas weft way bending length is decreased for both the weaves.

For rib weave, the parameter weft way bending length/GSM decreases on woollenisation whereas for plain weave the difference is marginal [Fig. 2(a)]. Table 4 shows that the fabric softness is improved after woollenisation treatment which is manifested as the drop in drape coefficient for both the weaves.

Figure 2(b) shows the effect of woollenisation on the parameter drape coefficient/GSM. Drape coefficient/GSM decreases for rib weave, whereas it is not appreciably affected for plain weave. This difference between plain and rib weave may be due to difference in jute content of the two weaves.

Table 4 shows effect of woollenisation treatment on tensile properties. It can be observed that for both the weaves, there is reduction in weft way tensile strength having presence of jute weft. This may be due to modification in chemical structure of jute due to partial removal of hemicellulose content in jute fibre. Extension of the jute weft at break increases after woollenisation due to introduction of crimpiness. There is marginal change in warp way tensile strength.

After woollenisation weft way tensile strength/GSM for both plain and rib weaves are reduced to 0.0826 kgf/g/m$^2$ and 0.1153 kgf/g/m$^2$ respectively.

3.3 Effect of Softening on Fabric Properties

Table 5 shows that the fabric softness after softening treatment is improved which is manifested as the drop in

<table>
<thead>
<tr>
<th>Weave</th>
<th>Bending length, cm</th>
<th>Tensile properties</th>
<th>% Drape coefficient</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Scoured</td>
<td>Woollenised</td>
<td>Scoured</td>
</tr>
<tr>
<td>Warp</td>
<td>Weft</td>
<td>Warp</td>
<td>Weft</td>
</tr>
<tr>
<td>Plain</td>
<td>3.13</td>
<td>4.96</td>
<td>3.17</td>
</tr>
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<td>Rib</td>
<td>3.16</td>
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<td>3.12</td>
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<table>
<thead>
<tr>
<th>Weave</th>
<th>Bending length, cm</th>
<th>Tensile strength, kgf</th>
<th>% Drape coefficient</th>
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</thead>
<tbody>
<tr>
<td></td>
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<td>Softening</td>
<td>Scoured</td>
</tr>
<tr>
<td>Warp</td>
<td>Weft</td>
<td>Weft</td>
<td>Weft</td>
</tr>
<tr>
<td>Plain</td>
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<td>3.55</td>
<td>4.96</td>
</tr>
<tr>
<td>Rib</td>
<td>3.16</td>
<td>3.38</td>
<td>6.51</td>
</tr>
</tbody>
</table>

Fig. 2—Effect of woollenisation on various parameters [(a) weft way bending length/GSM, and (b) drape coefficient/GSM]
weft way bending length. Softening treatment reduces intra- and inter-fibre friction which makes fabric more pliable and hence bending length decreases. Warp way bending length is increased which may be due to shrinkage.

Figure 3(a) intends to show influence of softening treatment on weft way bending length/GSM of the fabric. There is reduction in weft way bending length after softening for both the weaves. It is observed that drape coefficient increases after softening treatment which does not reflect any improvement in fabric softness. However, increase in drape coefficient may be due to shrinkage. Parameter drape coefficient/GSM is found to reduce for both the weaves after softening treatment [Fig. 3(b)].

Table 5 also shows that warp way and weft way tensile strength reduces after softening treatment for both the weaves. This may be attributed to slippage caused due to reduction in intra- and inter-fibre friction during tensile loading. After woollenisation weft way tensile strength/GSM for both plain and rib weaves are reduced to 0.0788 kgf/g/m$^2$ and 0.0963 kgf/g/m$^2$ respectively.

### 3.4 Effect of Enzyme Treatment Followed by Softening on Fabric Properties

Jute-cotton union fabric was given enzymatic treatment followed by softening, in which acid cellulase enzyme treatment was followed by polymer softener application. Enzyme treatment removes surface cellulosic fibres from jute and softening treatment reduces intra- and inter-fibre friction.

Table 6 shows that the fabric softness after enzyme followed by softening treatment for rib weave is improved only weft way. For plain weave, no significant change in bending length is observed warp way as well as weft way. It can be observed from Fig. 4(a) that weft way bending length/GSM is reduced after enzyme followed by softening treatment for both rib and plain weaves.

![Fig. 3—Effect of chemical softening on various parameters [(a) weft way bending length/GSM, and (b) drape coefficient/GSM](image1)](image1)

![Fig. 4—Effect of enzyme treatment+chemical softening on various parameters [(a) weft way bending length/GSM, and (b) drape coefficient/GSM](image2)](image2)

<table>
<thead>
<tr>
<th>Weave</th>
<th>Bending length, cm</th>
<th>% Drape coefficient</th>
<th>Tensile strength, kgf</th>
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<tr>
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<td>Enzymes + softening</td>
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way bending length/GSM decreases for both weaves after enzyme followed by softening treatment. After enzyme treatment followed by softening, drape coefficient drops for both the weaves which shows an improvement in fabric softness. This improvement can be attributed to reduction in surface hairs of jute fibres due to enzyme treatment and lubricating effect of softener. Figure 4(b) shows that there is no significant change in drape coefficient/ GSM for both weaves.

Table 6 also shows effect of enzymes followed by softening on tensile strength. It can be observed that there is drop in warp way as well as weft way tensile strength for both the weaves. This drop may be due to reduction in surface cellulosic fibres caused by enzyme treatment as well as slippage due to lubricating effect of softener. Figure 4(c) shows weft way tensile strength/GSM after the enzymes followed by softening. Weft way tensile strength/GSM reduces after the enzymes and softening treatment for both the weaves. After woollenisation weft way tensile strength/GSM for both plain and rib weaves are reduced to 0.0821 kgf/g/m² and 0.1336 kgf/g/m² respectively.

4 Conclusion

4.1 Fabric handle of a plain and rib woven jute-cotton union fabric is improved by all four treatments, as reflected through reduction in drape coefficient.

4.2 Reduction in bending length on wet treatment reflects improvement in fabric handle. Each treatment is not found to reduce bending length. Bending length reduces for a particular weave with particular treatments only. Fabric shrinkage on wet treatment also influences bending length.

4.3 Subjective evaluation shows that general fabric handle is improved by all finishing treatments for both the weaves. Among all treatments, sequential bleaching is judged to be the best treatment for both the weaves.

4.4 Fabric tensile strength is reduced by all four treatments which indicate influence of wet treatment on fabric. Reduction in tensile strength may be due to partial removal of hemicellulose from jute component or reduction in inter-fibre/inter-yarn friction (in case of softening treatment).

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References