Pull-out behaviour of yarn from plain woven jute fabric

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Received 14 July 2005; revised received and accepted 2 February 2006

Effects of calendering and bending length on pull-out behaviour of yarns from five different sets of commonly used jute hessian fabrics have been studied. Force required to pull out yarn from the fabric is measured in tensile testing machine. The pull out characteristics of the yarn adjacent to the yarn which has previously been pulled out is also studied. Lesser pull-out force is observed in case of calendered samples, and the load to pull out the adjoining yarn, which is beside the yarn that has already been pulled out, is found to be comparatively much less.

Keywords: Bending length, Calendering, Jute hessian fabrics, Weaving

IPC Code: Int. Cl. C08D033

Pull-out behaviour of yarn from woven fabric is important to understand the mechanism of yarn interactions within the fabric. This yarn interaction at the crossover points is the essential feature of woven fabric, specially for structurally opened fabric like jute used as packing, for which the yarn pull-out behaviour is very important during package handling.

Kendall suggested that the pull-out force is measured on the basis of resistance to slippage for which it is necessary to produce a movement of warp thread over weft thread or vice-versa with the possibility of prediction of load during yarn slippage and yarn pull-out. Taylor observed the effect of yarn pull-out force on fabric properties. Aswani et al. experimentally showed highly correlated linear relationship between resistance to abrasion of fabric and thread slippage. Sebastain et al. observed the reduction of inter-yarn adhesion and inter-yarn sliding friction by softening treatment. They also reported the reduction in tensile modulus of the yarns and the increase in deformability in sheared of the fabric. However they were unable to suggest among these two which one is the predominant factor during yarn pull-out. Motamedi et al. manifested the influence of fabric side tension on yarn pull-out behaviour and the micro displacement of cross yarn during pulling out of yarn from woven fabric. They found that as pull-out force increases, the fabric gets distorted and the pulled out yarn extends till a critical force is applied when crossover points are ruptured, and after a short phase of intermittent motion, the rest of the pull-out is proceeded in a smoother manner by the decrease in proportion to the number of remaining crossover contacts. The significant general finding is that the mechanical deformation of the weave during initial deformation prior to junction rupture might be accounted for by using a common tensile stress-strain curve for a free yarn. Similar to the assumptions made by Cox in shear lag theory, Pan and Yoon assumed that the extensional stress in the fabric region formed by adjacent yarn is negligible in relation to that particular yarn which has already pulled out. As long as the pressure at the crossing points is low and kept constant, the yarn pull-out force would be constant in the fabric where the yarn surface characteristics or frictional behaviour were given. Pan and Yoon proposed that the interaction at the crossover point is the only mechanism through which the yarn in two orthogonal and otherwise isolated systems forms an interlocked fabric system with fairly high strength. They also showed that for different fabric weave structures and yarn types, the yarn pull-out behaviour is also different. The critical yarn embedded length is proportional to the yarn tensile breaking load and inversely proportional to the maximum yarn pull-out force at a given embedded length.

The present work is aimed at studying the pull-out behaviour of yarn from five different sets of square jute hessian fabrics in calendered and non-calendered forms. The pull-out behaviour of the adjacent yarn which is beside the yarn that has already been pulled out is also analysed.

All fabric samples were prepared from 267 tex warp and weft yarns widely used by the industry. Five sets of commonly used square jute hessian fabrics were prepared in non-automatic shuttle loom and one part of each sample was calendered. The fabric parameters of both calendered and non-calendered samples are given in Table 1.

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Table 1 — Fabric sample specifications

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<th>Ends/dm</th>
<th>Non-cal</th>
<th>Cal</th>
<th>Picks/dm</th>
<th>Non-cal</th>
<th>Cal</th>
<th>Crimp %</th>
<th>Non-cal</th>
<th>Cal</th>
<th>Cloth weight, g/m²</th>
<th>Non-cal</th>
<th>Cal</th>
<th>Thickness, mm</th>
<th>Non-cal</th>
<th>Cal</th>
<th>Bending length, mm</th>
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Non-cal — Non-calendered, and Cal — Calendered.

Fabric sample of 10cm² size was screwed in between two identical U-shaped plates. The bottom part of the plate was held by the lower jaw of the Intron tensile tester and the upper jaw hold the yarn to be pulled out which was 3 cm longer than other yarns of the specimen. The schematic diagram is shown in Fig.1. The cross-head speed was 50mm/min. Before the jaw separation, the bottom part of the yarn to be pulled out was cut at close proximity to the U-shaped plates. After recording the initial maximum load, the load values at 20, 40 and 60mm yarn pull out were measured by operating the display board. Similar technique was followed to determine pull-out behaviour of adjacent yarn. The results are shown in Figs 2 and 3.

Table 1 shows that for jute hessian fabrics, the calendaring has considerable effect on fabric parameters like warp crimp, cloth weight and fabric thickness but changes in ends and picks per unit length and weft crimp are marginal.

The bending length of non-calendered samples are higher than that of the calendered samples. This may be due to the reduction in thickness where rounder yarns have become more flatter, providing less resistance to bending although fabric areal density is reduced in case of calendered samples (Table 1).

Figure 2 shows that the sample S-1 (closest construction) has maximum force to pull out the yarn followed by the next closest construction (sample S-2) and this trend is followed through out. The pull-out behaviour shows that the initial developed load is due to the static friction at the beginning till it reaches to a limiting value after which yarn starts sliding. The load value is decreasing gradually as holdings of sliding yarn at crossover points are decreasing. This is in agreement with the results observed by Kendall, Taylor’s and Aswani et al. Fabric structure plays an important role, as also shown by Pan and Yoon.
less, resulting in lesser crimp amplitude. On the other hand, the bending length is less in calendered samples, making the fabric more flexible. These changes in fabric properties facilitate easy withdrawal of yarn from the fabric samples. Sebastain et al.\textsuperscript{4} highlighted similar behaviour by softening treatment.

When the load to pull out the adjacent yarn which is beside the yarn that has already been pulled out is considered, it is observed that in case of non-calendered samples average drop in load to pull out is about 50\%, whereas in case of calendered samples this value is about 60\% (Figs 2 and 3). The results also indicate easy pull-out phenomenon of yarn from calendered samples (Fig. 3).

Yarn from the jute hessian fabric can be pulled out easily when the fabrics are calendered. Load to pull out the adjoining yarn, which is beside the yarn that has already been pulled out, is comparatively much less. Although calendered samples exhibit smoother and better surface appearance, it is advisable to use non-calendered samples for some specific end uses in packaging system like cement bag and food grain packaging where hooks are used during material handling.

References