THE MECHANICAL BEHAVIOR OF COTTON AND COTTON/POLYESTER YARNS SUBJECTED TO ENZYME TREATMENT

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Abstract

This work evaluated the changes in the low-stress mechanical behavior of 100% cotton and cotton/polyester yarns subjected to enzyme treatment. Yarns representing structural differences as defined by different spinning systems were enzyme treated under identical treatment conditions. The treated yarns showed widely different weight losses, suggesting that structural parameters such as density of fiber packing, fiber distribution in the cross-section, and fiber orientation may be influencing the rate of cellulose erosion in the treated yarns. The treated yarns in general showed higher thickness compression and higher compression energy, indicating marked improvement in softness. Most treated yarns also showed reduced values for bending stiffness and bending hysteresis. The extent of change in individual properties was found to be related to the spinning system used. Based on the observed changes in mechanical properties, it can be expected that the fabrics made from the treated yarns would be softer and less stiff to bend.

Introduction

Enzyme treatment of cellulosic textiles is of recent origin. Recent publications dealing with enzyme treatment suggest that the treatment is mostly carried out on woven or knitted fabrics to achieve a range of end effects. It is also clear that recent work mainly focused on the impact of enzyme treatment on fabric preparation, dying and finishing. Focus on the hand related properties appears to be very limited. Also there is practically no work on yarns; no work could be found on the property changes of spun yarns representing different spinning systems. An understanding of how exactly the treatment conditions interact with the yarn structure and blend composition may reveal new ways of improving the hand qualities of fabrics made from rotor, air-jet and friction spun yarns. Thus there is a definite need to understand how enzyme treatment conditions and yarn structure interact to produce changes in the hand-related properties of spun yarns.

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Objectives of Present Work

Following are the objectives we identified for this work.

1. Understand the influence of enzyme treatment on the hand related mechanical behavior of yarns.
2. Explain changes in fabric properties on the basis of the changes observed in yarn properties.
3. Obtain a preliminary understanding of how enzyme treatment influences the properties of yarns made on different spinning systems.
4. Promote enzyme treatment as a new tool to improve the hand properties of fabrics made from unconventional yarns.
5. Develop guidelines for the enzyme treatment of yarns/fabrics representing different spinning systems.
6. Develop guidelines for the enzyme treatment of blended yarns.

Experimental Yarns

The work covered two groups of yarns. Group I represented a set of cotton/polyester yarns, which contained staple polyester fiber as a minor blend component in random distribution and core concentration modes. This group also used a 100% cotton yarn and a cotton/polyester core-sheath yarn with a filament core for comparison purposes.

Group II yarns were all 18s (Ne) 50:50 cotton/polyester yarns. They were made from the same fiber stock (same sliver), but they represented three different spinning systems (ring, rotor and air-jet spinning systems).

Treatment Conditions

Both groups of yarns used the same cellulase enzyme and the same treatment conditions. Amount of enzyme used was 10% on the weight of yarn. The buffer solution was 0.05 M sodium acetate solution. Liquor ratio used was 100ml of water for each gram of enzyme. The treatment temperature was 37±1 ^{0}C, and the pH of the treatment bath was 4.8. The duration of treatment was one hour. The yarns were converted into skeins and the self-twisted skeins were folded back to a six-inch bundle. The folded bundle was loosely tied at two places, three inches apart. The tied yarn bundle was then immersed in the enzyme solution and treated for one hour under mildly shaking conditions, before deactivating the enzyme with the buffer solution.

Measurement of Yarn Properties

We measured the following properties of the treated and untreated yarns to characterize the effect of treatment on the individual mechanical properties. We used the Kawabata

bending and compression testers to measure the compression and bending properties. The tensile properties were measured on the Instron tester.

Compression
- LC: linearity of compression
- WC: compression energy (gf•cm/cm^2)
- RC: compression resilience (%)
- EMC: thickness compression (%)

Bending
- B: Bending Rigidity (gf•cm/cm^2)
- 2HB: Bending Hysteresis (gf•cm/cm)

Tensile
- Breaking load (lb.)
- Breaking elongation (%)

Optical Microscopy
- Magnified photographs of treated and untreated yarns

SEM
- Scanning electronic micrographs of surface fibers for treated and untreated yarns.

Statistical Analysis

We carried out t-tests to see if the difference in measured properties of the treated and untreated yarns are statistically significant. We used the ANOVA test to characterize the statistical significance of the measured properties of the yarns representing different spinning systems and different fiber distributions.

Conclusions

- Based on the statistical analysis of the test results, we arrived at the following conclusions:
- Cotton/Polyester yarns representing core-sheath construction and random fiber distribution showed different weight losses under identical treatment conditions.
- 100% cotton yarns representing ring, rotor, and friction spinning technologies also showed widely different weight losses under identical treatment conditions.
- Friction yarn showed roughly 4 times weight loss compared to ring yarn and rotor yarn showed roughly 2.5 times weight loss compared to ring yarn.
- The huge differences in the measured weight loss of yarns treated under identical conditions suggest that density of fiber packing, fiber distribution, and fiber orientation may affect the rate of cellulose erosion in treated yarns.
- The treatment conditions used in this study showed noticeable cellulose erosion in the surface fibers of predominantly cotton yarns.
- Treating the yarn in the form of a self-twisted skein proved to be simple and convenient but the treated yarn showed excessive hairiness.
- Treated yarns showed increased compression energy (WC), increased thickness compression (EMC%), and reduced compressive resilience (RC%). This trend was true for both group 1 and group 2 yarns.
- Most treated yarns also showed reduced values for bending modulus and bending hysteresis. This trend was also true for both groups.
- Based on the change in properties, it can be stated that the treatment produces desirable changes in the compression and bending properties of yarns. Enzyme treatment therefore appears to have the potential to improve the hand quality of cotton rich fabrics made from the unconventional yarns.
- The extent of change in bending and compression properties was found to be related to the spinning system and yarn structure.
- Based on the observed changes in yarn compression and bending properties, one can expect maximum improvement in hand quality for fabrics made from air-jet spun poly/cotton yarn, and friction spun 100% cotton yarn.
- Yarns representing different spinning systems show major differences in yarn compression and bending properties. Enzyme treatment in general contributes to a reduction in the property difference between spinning systems.
- The breaking strength and breaking elongation of treated cotton yarns showed only a marginal reduction (in the range of 2-10%) compared to that of the untreated yarns.
- All three Cotton/Polyester yarns also showed a slight drop in strength after enzyme treatment.