PROPERTIES OF YARN MADE FROM BROKEN COTTON FIBER

John B. Price, Kearny Q. Robert, and Timothy A. Calamari
Southern Regional Research Center
USDA, ARS
New Orleans, LA

Abstract

A pilot study was performed with the intent of: (1) assessing the feasibility of a statistic proposed to more adequately describe fiber damage, and (2) to identify those problems which must be overcome in further work. The study was conducted on a relatively small quantity of each of four cottons, to provide experience in the processing of cottons which had been combed, cut, and then re-carded. Comparisons were made with normally carded yarns and combed, re-carded yarns. The properties of the resultant yarns were related to fiber data to give an indication of the utility of statistics which describe the length distribution. Combed fibers pack more densely, requiring that the batt draft and the total card draft be increased by about 12 and 38%, respectively. Combed fibers are of lower cohesion, requiring optimization of cardweb draft and sliver linear density, and reduction in delivery speed, as well as optimization of drawframe settings. Shorter fibers require an increase both in the linear density of the roving and in the twist inserted. A non-rigorous statistical analysis indicated that, of all the simple statistics provided by the Peyer Almeter instrument which may be considered to be indicative of fiber damage, mean length was best, even surpassing short fiber content. The Quality Factor was even better.

Introduction

One of us (Robert) has proposed the Quality (or Q-) Factor (the mass fraction of unbroken fibers) as a means of more completely characterizing the damage incurred by cotton fibers during their conversion into textile materials. To date there has been no truly quantitative assessment of the ramifications of fiber damage beyond the form of sliver.

This work was conducted as a pilot for a larger study which we intend to perform to demonstrate the value, or hopefully the superiority, of the Quality Factor over other measures which are related to fiber damage. It was not designed to yield data which could be subjected to rigorous statistical analysis, but to give experience in the handling of broken fibers, provide a practical application of the Quality Factor, and suggest the design of future experiments.

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 1:727-729 (1997)
National Cotton Council, Memphis TN

Raw Material

Four cottons were used for this study, each intended to be representative of one of the four major growth areas of the United States. They were designated Pima, Acala, Delta and West Texas. The HVI test data are shown in Table I.

Procedure

1. Production of Carded Samples

Each cotton was converted into card sliver using a normal processing sequence. From the bale, the cotton was opened and cleaned with our standard equipment, and carded at about 70 lb/hr (60 lb/hr for Pima). About 20 lb. of each card sliver was converted into second passage drawframe sliver, then into roving, to provide the lots of carded stock from which to spin yarns.

2. Production of Cut Combed Samples.

The remaining card sliver from each lot was then combed with the usual sequence of machinery . After a preliminary process of drawing, eight laps were made to provide feed-stock for the combing process. The combed sliver was formed into 15 lb. lots, one of which was fed through an air venturi device to individualize the fibers as much as possible. The remaining lots were passed, four slivers at a time, through a staple cutter to provide lots of cut lengths 4, 2, and 1 inch where quantities permitted. Properties of the damaged cotton fiber are discussed in detail elsewhere (Robert 1997).

Each lot of combed fiber, cut and uncut, was converted back into card sliver by processing through the same sequence of machinery used to produce the carded lots of each type of cotton. Each card sliver was then processed into roving prior to spinning. A small quantity of each of the card slivers produced was taken for the determination of fiber length distribution characteristics.

3. Experiences in Processing

Our experiences in processing can be summarized as follows:

(i) Combed fibers pack more densely. Consequently, the batt draft (the draft between chute delivery rolls and card feed rolls) was increased about 12% to prevent overfeeding. The total card draft was increased by 38%, also.

(ii) Combed fibers are of lower cohesion. The difficulty of handling increased as the fiber length reduced, requiring careful optimization of the card web draft and choice of sliver linear density. The delivery speed was reduced from 123 m/min to 64 m/min (135 to 70 yd/min).

(iii) Second passage drawframe sliver could not be produced from those fibers which had received the most damage by cutting (25 mm cut length). Lack of sliver cohesion between delivery and calender rolls caused numerous stoppages. In such cases, the first passage drawframe sliver was inverted to form a supply for the production of roving.

(iv) Expecting that it would be more difficult to produce roving from the shorter and more heavily-damaged fibers, it was decided to produce roving of 2.0 hank from the longest cotton, Pima, and 1.0 hank from the shortest cotton (West Texas). Increased twist levels were used for those fibers which were cut.

4. Spinning

Attempts were made to spin three yarns (Ne 16, 22, and 30) from each of the rovings so produced. Particularly at this stage, it was found that the selection of twist for the rovings had been a little timid, intended to avoid overtwisting the roving and causing drafting problems at the ring frame. Including all produced by cutting at a gauge length of 1 in., several lots could not be satisfactorily spun into yarn due to excessively high breaks in the creel. All other yarn samples were produced essentially without interruption, spinning sufficient yarn for the determination of skein strength, tensile properties (Uster Tensorapid) and non-uniformity (Uster Evenness Test).

Results and Analysis

Yarn strength was reduced as finer yarns were spun. The combed uncut cotton gave the strongest yarn, followed by the carded lot. The weakest yarns were produced from the cotton which had been damaged the most. The trend lines were all approximately parallel. The strengths of solely carded fibers lay between combed uncut and combed fibers having been cut in sliver to a 4 in. gauge. This was common to all cottons.

Yarn tenacity and yarn strength as determined by skein testing were found to be closely related. The trends shown in skein strength data were, therefore, reflected in single yarn tensile strengths as measured by the Uster Tensorapid.

The effect of fiber damage on yarn evenness was that irregularity increased with fiber damage, and carded yarn evenness lay between the evenness values of yarns from combed uncut cotton and combed "4-in." cut cotton. As observed with yarn strength, the linear relationships with yarn number for each preparation of cotton were approximately parallel. The inference to be drawn from this fact is that the rate at which yarn properties change with yarn number is relatively independent of fiber length. Fiber length, however, influences the level of strength or irregularity.

Regression Analysis

1. Carded Yarns

A series of regressions for the count strength product of yarns spun from each of the four carded cottons were made on various combinations of fiber properties determined on bale samples. A better explanation of yarn strength was obtained by using mean length rather than the upper length statistic or fiber strength (with which location measures of the length distribution had a high mutual association, the correlation coefficients being 0.85 and 0.96, respectively). Variation of yarn strength was almost totally explained by the linear density of the yarn, mean length and Micronaire Value. The inclusion of a fourth independent variable increased the residual standard deviation. A similar pattern was observed among the combed uncut yarn data.

2. Yarns from Re-Carded Combed Fiber

A data set was formed using the strengths of yarns spun from all re-carded, combed fibers, both cut and uncut. Using the three independent variables of linear density, mean length and Micronaire, a number of damage-related statistics were introduced in turn as a fourth independent variable to be used to derive a multiple linear regression equation for yarn strength. The set of damage-related properties included the estimated length distribution data and several damage-related parameters (Table II). The regression data show that mean length is the best classical length distribution statistic to use to assess damage. A superior explanation of the variation in yarn strength, however, is apparent when the Q is used instead, R increasing from 0.965 to 0.972.

The Quality Factor, Q, was derived using weight-biased distribution data. If calculated using number-biased distribution data and entered as the fourth variable then the explanation of yarn strength was inferior. The proportion of original yarn strength was calculated by dividing the measured yarn strength by the strength of the yarn of the same nominal linear density spun from re-carded uncut combed fibers. When plotted against Q, a linear relationship with a coefficient of determination of 90% was suggested. On average the ratio of carded to combed, re-carded yarn strength was 92.6%, equivalent to a Quality Factor of 90%. (Interestingly, the equivalent ratio was 89.2% for the Pima cotton, equivalent to a Quality Factor of 85% implying that the longer cotton had experienced greater damage.) This suggests that textile processing breaks at least 10% of the fibers by mass.

Conclusions

1. Reprocessing combed and cut combed fibers requires considerable changes to the settings of machinery set to handle carded cottons. These include increasing batt and total drafts at the card, producing heavier sliver at slower speeds and heavier rovings at higher twist levels.

2. Quality Factor appears to be more effective at describing the influence of fiber damage on yarn strength than other measures, including familiar length distribution parameters.

3. Textile processing can damage at least 10% of the cotton fibers.

Notes

The Southern Regional Research Center is one of the facilities of the Mid South Area, Agricultural Research Service, U.S. Department of Agriculture. Names of companies or commercial products are mentioned solely for the purpose of providing specific information; their mention does not imply recommendation or endorsement by the U.S. Department of Agriculture over others not mentioned.

References

Robert, K. Q., J. B. Price, X. Cui, and T. A. Calamari. 1997. Properties of broken cotton fiber. Proceedings Beltwide Cotton Conferences (this volume).

Table I. Summary of fiber properties (SpinLab HVI 900).

Fiber Property	Cotton Type			
	Pima	Acala	Delta	West Texas
Strength (g/tex)	43.27	29.44	26.09	30.24
Elongation (%)	12	9.7	8.5	11
Length (in)	1.361	1.195	1.113	1.069
Mean Length (in)	1.176	0.918	0.887	0.875
Uniformity (%)	86.4	76.8	79.7	81.8
Micronaire	4.2	4.2	5.2	4.6

Table II. Multiple linear regression statistics of yarn strength regressed against a fourth independent variable in addition to: (1) yarn number, (2) mean length, and (3) micronaire value. (All combed cottons).

Fourth Independent Variable	Regression Data	
	R^2 - value (adj.)	Standard Error
(none)	0.812	252
Coefficient of length variation	0.944	138
Short fiber content	0.944	137
Length uniformity	0.944	137
Upper quartile length	0.949	131
Mean length	0.965	109
Cut probablility	0.916	169
Damage Probability	0.965	109
Quality Factor (number-biased)	0.963	112
Quality Factor (mass-biased)	0.972	98