COTTON LENGTH UNIFORMITY AND YARN STRENGTH

J.D. Bargeron III
USDA-ARS-CQRS
Clemson, SC

Abstract

There is considerable interest among textile manufacturers regarding the shorter fibers of a cotton's length distribution. The relationship between a cotton's short fiber content (SFC) and processing waste during opening, carding and spinning is an obvious one. The relationships between SFC and spinning efficiency, yarn evenness, and yarn strength are more difficult to establish. Apparently, mature strong cottons maintain their original length distributions better than immature weak cottons. For a given high volume instrument (HVI) the upper half mean length (UHM) and the length uniformity index (UI) tends to vary directly with fiber bundle strength. As the bundle strength decreases, so does the UI.

Introduction

SFC is defined as the percentage of fibers by weight less than 12.7 mm in length [ASTM 1440-90]. The relationship between SFC and HVI length UI of cotton is given by Zeidman [Zeidman, et al., Part I, 1991, Zeidman, et al., Part II, 1991]. A comprehensive survey of the SFC and UI literature is presented in the review article prepared by Behery [Behery, 1993]. Processing waste generated during textile manufacturing varies directly with the SFC of the cottons [Griffin, et al., 1982]. The actual amount of waste depends on the specific manufacturing methods employed. The SFC of a cotton is a function of the maturity or micronaire of the cotton, if equal fiber perimeters are assumed [Morton, 1962]. When a cotton's SFC is determined it is similar to taking a person's body temperature. If the reading is elevated, it is an indication of the health or vigor of the subject. A cotton with an elevated SFC will continue to generate additional short fibers as it is stressed during processing [Griffin, et al., 1982]. The objective of this study was to investigate the relationship between length distribution and yarn strength.

Methods

Nine hundred sixty-nine Upland cottons were evaluated for this study. They represented several varieties, production areas, harvesting methods, and growth years. Each cotton was tested for HVI length, strength, and fineness. Additionally, Suter-Webb arrays were performed on the cottons. The cottons were spun into 27 tex ring yarn. The skein break factors (BF) were determined for the yarns.

Linear and partial least squares (PLS) analyses were used to examine the data [Steel and Torrie, 1980]. A PLS model consisting of three principle components was used to model yarn strength. It was assumed that one component each represented the effects of length, strength, and fineness. All variables were expressed as standard normal deviates to facilitate the comparison of regression coefficients.

Results

These cottons ranged from an HVI UHM length of 23.9 to 30.7 mm, bundle strength of 19.6 to 34.0 g/tex, micronaire reading of 2.7 to 5.4, and length UI of 76 to 85 percent. Ninety-nine of the cottons had an UHM length of 27.9 mm. This subset was used for the initial analysis. It ranged in UI from 78 to 83 with the associated SFCs of 15% to 9%. The BF for the 27.9 UHM length cottons ranged between 1600 to 2400 units. On average for each 1% increase in SFC there was an allied decrease of 150 BF units in yarn strength. Interestingly, the average fiber strength of these cottons also decreased. Figure 1 presents the fiber strengths versus UI for these cottons. The average fiber strength for length UI 78 was 25.4 g/tex, 79 was 24.8, 80 was 25.8, 81 was 26.4, 82 was 28.2, and 83 cottons was 27.1. The relationship between UI and fiber strength indicates a decrease of more than 0.5 g/tex for each percentage decrease in UI. The decrease in yarn strength with the increase in SFC could likely be attributed to these reductions in fiber strength. Two additional subsets of the 969 cottons were selected. Forty-five cottons which had UHM lengths of 27.2 mm and 75 of 28.7 mm were examined. These subsets followed the same trends as the 27.9 mm cottons.

A PLS model, using the 99, 27.9 inch cottons, for yarn strength versus fiber length strength and fineness gave a regression coefficient for Suter-Webb upper quartile length of 0.153, HVI strength of 0.502, micronaire of -0.226, and SFC of -0.276. These coefficients indicate that the variations in yarn strength are likely more associated with variations in fiber strength than fiber length. To further explore the effects of fiber length and SFC on yarn strength, a PLS model using all 969 cottons was

created. Figure 2 presents these results. The regression coefficient for array length group 1 was -0.88, for 3 was -0.113, for 5 was -0.138, for 7 was -0.097, for 9 was -0.065, for 11 was -0.009, for 13 was 0.012, for 15 was 0.013, for 17 was 0.027, for 19 was -0.030, for 21 was 0.043, for 23 was 0.082, for 25 was 0.122, for strength was 0.397, and micronaire was -0.257. Group 5 is the length that was most highly associated with yarn strength.

Discussion

Each of the 969 study cottons was suitable for manufacturing 22's Ne carded yarns. The effect of changes in fiber strength had about twice the effect as changes in SFC on the resultant yarn strength. It is postulated that the decreases in strength of the fibers is likely responsible for the increases in SFC of the cottons. Strong mature cottons should be better able to maintain their as grown length distribution than weaker immature cottons. The length distributions of weaker cottons are likely to become more skewed toward the shorter length groups during ginning and lint cleaning.

The designation of fibers less than 12.7 mm as SFC does appear a little arbitrary. Certainly, the fibers less than 9.5 mm were the most interesting in this study. It is unclear as to the advisability of using a fixed length designation of short fiber with effective lengths that can vary from 22.9 to 30.5 mm. Some have suggested that what needs to be known for efficient textile manufacturing is the quantity of fibers that are out of control during drafting processes. This quantity would be a function of effective fiber length which dictates drafting roll spacing. Therefore as far as manufacturing performance is concerned a floating index such as length UI should be preferable.

Conclusions

It would be very difficult to project the results of this study onto other spinning plans. It is still unclear as to the usefulness of knowing the SFC of a cotton, except possibly as a waste factor. To infer resultant yarn properties, a normal SFC for a staple length must be known before an elevated level can be assessed. The length UI worked well as a performance indicator in this study. It is suggested that for a given effective fiber length that no additional length parameters, other than length UI, are required for the inference of yarn quality.

References

ASTM D 1440 - 90 Standard Test Method for Length Distribution of Cotton Fibers (Array Method), American Society for Testing and Materials, West Conshohocken, PA, Vol 07.01, pp 391-396.

Behery, H. M. 1993. Short Fiber Content and Uniformity Index in Cotton. CAB International. Oxon, UK. 40 p

Griffin, A. C., G. J. Mangilardi, J. D. Bargeron. 1982. Six-Stage Lint Cleaning: Effects of Fiber and Spinning Parameters. Proceedings of the Beltwide Cotton Research Conferences. National Cotton Council. Memphis, TN

Hamby, S. E. 1965. The American Cotton Handbook. Volume One. Interscience Publishers. New York, NY. 518 p.

Morton, W. E. 1962. Physical Properties of Textile Fibers. Butterworths. Manchester, UK. 608 p.

Steel, Robert G. D. And James H. Torrie. 1980. Principals and Procedures of Statistics. McGraw-Hill Book Company. New York, NY 633 p.

Zeidman, M. I., S. K. Batra, and P. E. Sasser. 1991. Determining Short Fiber Content in Cotton. Part I: Some Theoretical Fundamentals. Textile Research Journal. Vol 61(1) pp 21-30.

Zeidman, M. I., S. K. Batra, and P. E. Sasser. 1991. Determining Short Fiber Content in Cotton. Part II: Measurement of SFC from HVI Data--Statistical Models. Textile Research Journal. Vol 61(2) pp 106-113.

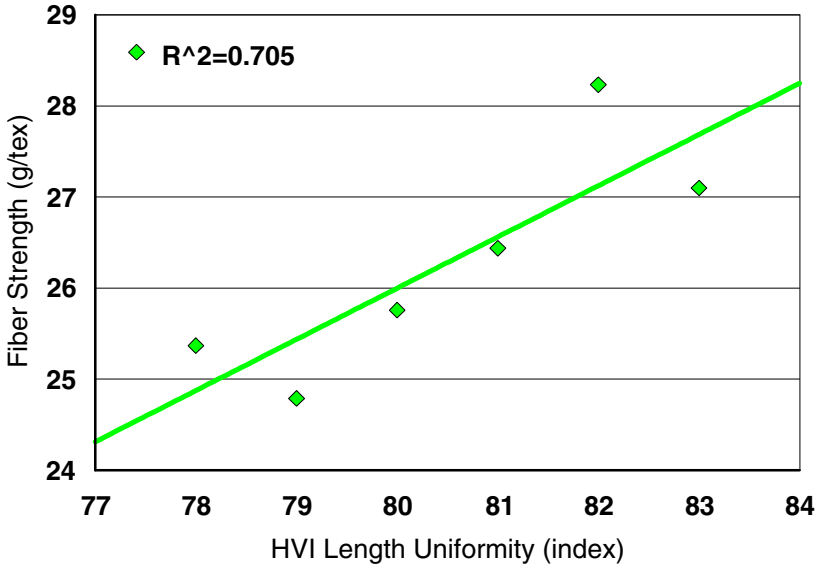

Figure 1. Fiber strength versus length uniformity.

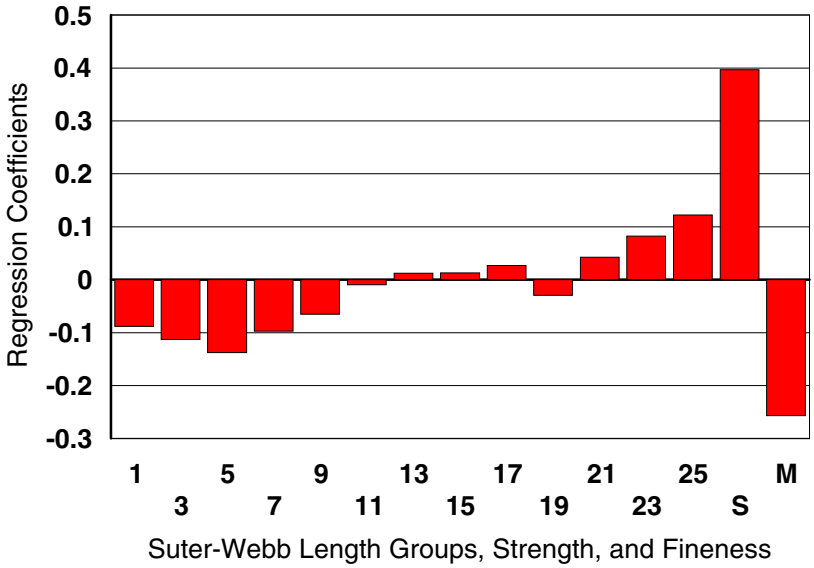

Figure 2. Partial least squares regression for yarn strength.