COTTON MATURITY AND FINENESS MEASUREMENT USING THE SIROLAN-LASERSCAN

G. R. S. Naylor
CSIRO Textile and Fibre Technology
Geelong, Victoria, Australia

Abstract

Using a set of cotton samples representing differing growing times, the present paper assesses the potential of the Sirolan-Laserscan to measure average fibre fineness. The measured results accurately reflect the expected variations in fibre fineness values for these samples. Combining these measured fibre fineness values with HVI micronaire data the paper illustrates that average maturity ratio values can also be obtained. Again for the set of samples measured the average maturity ratio values follow the expected trends. Further an independent simple test is developed to examine the internal consistency of the fineness and maturity ratio values for this set of samples. The Sirolan-Laserscan results pass this test unlike those obtained from the FMT.

Introduction

Commercially the presence of immature fibres in a blend can lead to significant textile problems including the formation of neps during processing and 'white speck' imperfections during dyeing. Fibre maturity can be measured directly from fibre cross-sections and Thibodeaux and Rajasekaran (1999) have used this approach in the development of reference standards for cotton fibre maturity. Unfortunately, this approach is inherently slow and hence not suitable as a commercial test. Despite considerable research effect no satisfactory commercial method is available for assessing fibre maturity. For example the Micronaire measurement is a mixture of both fibre fineness (mass per unit length) and maturity and for many cotton varieties the micronaire value may not be a good indicator of either property (Williams and Yankey, 1996).

Naylor and Sambell (1999) described the results of a preliminary study using a new approach to measure the fibre fineness of cotton samples independently of fibre immaturity. This approach utilised the Sirolan-Laserscan, a commercial instrument developed for the wool industry. This instrument developed at CSIRO is in commercial use for the rapid measurement of the full fibre diameter distribution of wool samples (IWTO, 1993). The technique suspends fibre snippets in an isopropanol-water mixture that transports them such that they cross the path of a laser beam. The fibre diameter of each fibre snippet is determined from its interaction with the laser light. Naylor and Sambell (1999) illustrated that the instrument in a novel mode of operation can indeed be used to determine fibre fineness accurately.

The current paper extends the earlier preliminary work.

Methodology

Samples from a plot of Sicala 40 cotton were hand picked at different times over the growing season to provide a range of fibre maturities. Unopened bolls were oven dried, opened by hand, and ginned in a 20-saw laboratory gin. The lint was characterised using HVI and FMT standard procedures.

Average fibre fineness was determined following the technique described previously (Naylor and Sambell, 1999). Samples were conditioned at 20 C and 65% relative humidity for at least 24 hours before taking measurements. Fibre snippets were then cut using a standard Sirolan-Laserscan guillotine from aligned 'beards' of fibres produced using the SpinLab Fibroliner. After weighing, the fibre snippets were fed into the Sirolan-Laserscan, which was set such that it continued to count until all the sample was exhausted. This yielded the total number of fibres N 'seen' by the instrument. (As the actual laser beam is smaller in size than the measurement cell, statistically only a proportion of the input snippets are registered by the Sirolan-Laserscan.) A predetermined instrument correction factor, α , is then applied to yield the total fibre snippets in the sample. The average fibre fineness (linear density) FF was then calculated by the formula:

$$FF = \alpha W/(NL) \qquad (1)$$

where W is the total weight of the snippets and L is the snippet length.

Results

Table 1 lists the details for the set of cottons examined together with their associated HVI and FMT results (Constable, private communication). Qualitatively these data follow the expected trend. For the first five samples the measured micronaire (both HVI and FMT values) and FMT fibre fineness and maturity ratio values all follow an increasing trend with an increase in growing period/fibre development. Similarly the reversal in this trend for the last sample is to be expected for the late developing bolls.

The FMT data can however be analysed a little more quantitatively. By definition, the maturity ratio M measures the portion of immature or 'dead' fibres and is related to the degree of wall thickening by

$$M = (4\pi * 0.577)A/P^2 \qquad (2)$$

where A and P are the cross-sectional area and perimeter of the fibre respectively (Thibodeaux, 1998). For a given cotton variety it is known that perimeter P is approximately constant. From Equation 2 it then follows that if P is constant, then fibre maturity M, is directly proportional to fibre cross-sectional area A ie fibre fineness. Using these relationships, Thibodeaux (1998) illustrated the linear relationship between fibre fineness FF and maturity ratio M for fixed fibre perimeter values. Interpolating from Figure 2 in Thibodeaux's paper

$$FF \approx 0.069 * P^2 * M \qquad (3)$$

where fibre fineness is measured in millitex and fibre perimeter in micrometres.

Equation 3 can be used as an independent test of the self consistency of the measured fibre fineness and maturity values for the current set of samples as they would be expected to have a constant value of the fibre cross-sectional perimeter P. Figure 1 shows a plot of the measured fibre fineness versus maturity ratio using the FMT indicating that the FMT results do not conform to Equation 3. It appears as though the FMT is overestimating the maturity ratio for the first few samples ie the very immature samples. This is not altogether surprising as Lord (1955) observed that in the Airflow approach, the simple linear relationship between the rate of airflow and specific surface area begins to break down for dense plugs of cotton (immature samples).

Table 2 and Figure 2 summarise the results for average fibre fineness values obtained using the Sirolan-Laserscan. Lord (1956) demonstrated that over a wide range of samples measured fibre fineness (FF), maturity ratio (M) and micronaire (Mic) are related by the equation

$$M*(FF) = 3.86*Mic^2 + 18.16*Mic + 13.0 \qquad (4)$$

Using this equation, the Sirolan–Laserscan average fibre fineness values combined with the HVI micronaire values determine maturity ratio values

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 2:1259-1261 (2001)
National Cotton Council, Memphis TN

M. These derived maturity values are also listed in Table 2 and plotted in Figure 2.

Qualitatively the trend in the measured average fibre fineness values and maturity ratio values are as expected, as explained above. Comparing these average fibre fineness and maturity ratio values obtained with the Sirolan-Laserscan with those obtained from the FMT, the Sirolan-Laserscan average fibre fineness values are somewhat larger and the derived maturity ratio values cover a wider range.

Following a similar quantitative analysis to that applied to the FMT data, Figure 1 also plots the Sirolan-Laserscan average fibre fineness values against the derived maturity ratio values. Also shown is the fit of this data set to Equation 3, ie a linear relationship passing through the origin. The Sirolan-Laserscan results are in much better agreement with Equation 3 than those obtained with the FMT. This independent test is added evidence of the validity of the measurement approach.

In summary, the Sirolan-Laserscan approach to measuring average fibre fineness correctly determines the trends of expected fibre fineness values as a function of growing time over the samples tested. When combined with HVI micronaire values, the Sirolan-Laserscan fibre fineness values can be used to determine average fibre maturity ratio values, which also follow the expected trends. Further, unlike the FMT values, the Sirolan-Laserscan values of average fibre fineness and fibre maturity ratio forms a self-consistent set for samples of fixed fibre cross-sectional perimeter.

Conclusion

The results presented add further positive evidence that the new approach of using the Sirolan-Laserscan to measure cotton fibre fineness and maturity ratio looks promising.

Acknowledgments

Financial assistance from the Australian Government and also a research grant from the Australian Cotton Research and Development Corporation is gratefully acknowledged. The author would also like to thank Dr. G. Constable and Mr. C. Tyson for providing the cotton samples and corresponding HVI and FMT values used in this work. Thanks also to Miss. L. O'Brien for her technical assistance.

References

IWTO Test method 12-93. 1993. Measurement of the mean and distribution of fibre diameter using the Sirolan-Laserscan Fibre Diameter Analyser,.

Lord, E. 1955 Air flow through plugs of textile fibres Part 1. General flow relations. J.T.I. **46**, T191-T213.

Lord, E. 1956 Air flow through plugs of textile fibres Part 2. The micronaire test for cotton. J.T.I. **47**, T17-T47.

Naylor, G.R.S. and J. Sambell. 1999. Measuring cotton fineness independently of maturity using the Sirolan-Laserscan. Proceedings Beltwide Cotton Conferences. 679-681.

Steadman, R.G. 1997. Cotton Testing, Textile Progress, 27(1).

Thibodeaux, D.P., and K. Rajasekara. 1999. Development of new reference standards for cotton fibre maturity. J. Cot. Sci. 3,188-193 (www.jcotsci.org/1999/issue04/xNote/art01/Page188.html).

Thibodeaux, D.P. 1998. Development of calibration cottons for fibre maturity. International Cotton Conference Proceedings, Bremen, ed H. Harig, S.A. Heap, J.C. Stevens. 99-107.

G.F. Williams and J.M. Yankey, New Developments in Single Fiber Fineness and Maturity Measurements. Cotton Quality Measurements Conference, Beltwide Cotton Conferences, 2, 1284-1289, 1996.

Table 1. Summary of Cotton Samples and Corresponding HVI and FMT Characterisation.

Harvest Date	Comment	HVI Data Mic.	HVI Data Mic	FMT Data Maturity	FMT Data Fineness
11/02/2000	Small Bolls –closed	2.1	1.7	0.63	76
11/02/2000	Large Bolls- closed	2.2	2	0.62	99
12/02/2000	Closed	2.5	2.4	0.61	127
02/03/2000	Large Bolls – closed	3.1	3.2	0.65	170
02/03/2000	Large Bolls - open mature	4.7	4.2	0.79	199
10/04/2000	Late Bolls – open	3.2	3.3	0.73	157

Table 2. Sirolan-Laserscan determined Average Fibre Fineness and Inferred Average Fibre Maturity Ratio Values.

Harvest Date	Comment	Fibre Fineness (mtex) Mean	Fibre Fineness (mtex) SD	Estimated Maturity Ratio
11/02/2000	Small Bolls – closed	102	6	0.54
11/02/2000	Large Bolls – closed	134	7	0.48
12/02/2000	Closed	147	9	0.54
2/03/2000	Large Bolls – closed	165	3	0.67
2/03/2000	Large Bolls - open mature	199	5	0.79
10/04/2000	Late Bolls – open	167	6	0.69

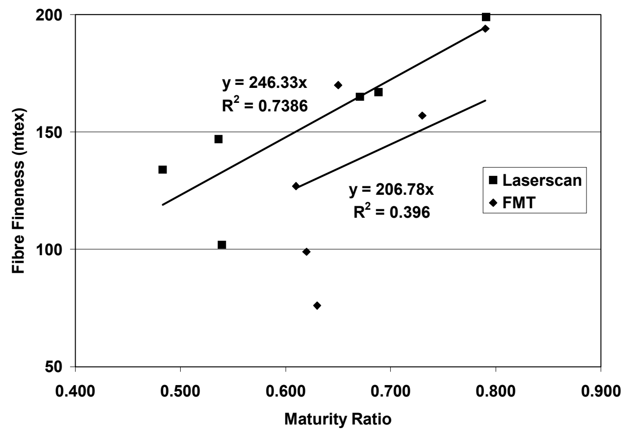

Figure 1. The relationship between fibre fineness and maturity ratio for two different measurement techniques.

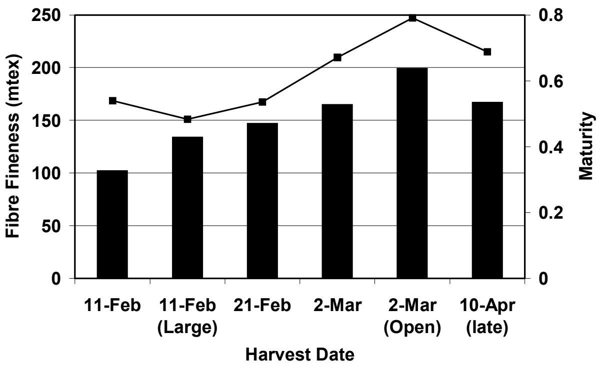

Figure 2. Summary of Average fibre fineness (bars) and inferred maturity ratio (squares) values obtained from the Sirolan-Laserscan.