MEASURING COTTON FINENESS INDEPENDENTLY OF MATURITY USING THE SIROLAN-LASERSCAN.

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Abstract

The micronaire measurement is a mixture of both fibre fineness (mass per unit length) and maturity. By comparison, the fineness of wool samples has, for many years, been determined using an airflow technique similar to that used for the micronaire measurement. Recently, CSIRO Wool Technology developed a new commercial instrument, the Sirolan-Laserscan, for the rapid measurement of the full fibre diameter distribution of wool samples. This preliminary project was designed to assess the potential of the Sirolan-Laserscan, in a new mode of operation, to measure cotton fineness independently of maturity. Thirteen cotton samples whose fineness and maturity values had been measured previously using the Shirley Fineness and Maturity Tester were used. These samples covered a broad range of both fineness and maturity values. A good correlation was found between the average fibre fineness measured by the Laserscan and the previously reported values.

Introduction

Cotton fibre fineness, sometimes referred to as linear density, and maturity are key quality parameters for cotton. The Micronaire measurement is a mixture of both fibre fineness (mass per unit length) and maturity. It has been estimated that micronaire represents two-thirds fibre fineness and one-third maturity (Steadman, 1997). Recent experience has shown that for many cotton varieties the micronaire value may not be a good indicator of either property (Williams and Yankey, 1996). This leads to ambiguity in commercial trading with sometimes a buyer arguing that a low micronaire reading denotes immaturity whereas the seller interprets it as fineness (Steadman, 1997).

In commercial trading, the fineness of wool samples has, for many years, been determined using an airflow technique similar to that used for the micronaire measurement. As wool fibres are approximately circular in cross-section, the results of this test are accurately interpreted as a mean fibre diameter. For the Australian wool clip, typical mean fibre diameter values are between 18 and 24 mm with differences of 0.1 mm being significant commercially.

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The Sirolan-Laserscan was developed at CSIRO Wool Technology as a commercial instrument for the rapid measurement of the full fibre diameter distribution of wool samples (IWTO, 1993). The technique, illustrated schematically in Figure 1, 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. The Sirolan-Laserscan technique is now an approved test method for commercial testing of wool samples and is being used by the trade worldwide.

The availability of fibre diameter distribution information for wool samples has lead to important advances at CSIRO Wool Technology on the role of diameter distribution in wool spinning (Lamb et al, 1992) and in fabric skin comfort (Naylor and Phillips, 1996). Some commercial mills are now specifying fibre diameter distribution characteristics and not just mean fibre diameter in order to control and improve their product quality.

Gordon (1995) tried to use the Sirolan-Laserscan to measure the properties of various cotton samples that he had characterised carefully as part of his Ph.D (Gordon, 1994). He observed some correlations between the Sirolan-Laserscan outputs and various fibre characteristics. For example, there was a relationship between the Sirolan-Laserscan mean fibre diameter and the fibre fineness. However Gordon noted that the sample of immature cotton was generally an outlier. Gordon concluded that none of his observations were statistically meaningful enough to warrant further investigation.

Methodology

In the Sirolan-Laserscan, fibre snippets, each approximately 2 mm long, are individualised and suspended in a carrier fluid. Single snippets are then counted and measured as they interact with a laser beam. Thus in principle the Laserscan gives two independent pieces of information, namely (a) the number of snippets observed and (b) fibre thickness. These two pieces of information form the key to a new approach for the Sirolan-Laserscan; a gravimetric determination of fibre fineness expressed as a weight per unit length (mtex).

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 fibres from 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, only a proportion of the input snippets are registered by the Sirolan-Laserscan.) A predetermined instrument correction factor, a, was then applied to yield the total fibre snippets in the sample. The average fineness (linear density) F was then calculated by the formula:

$$F = a\, W/(NL)$$

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

Results

Table 1 shows some preliminary results indicating the reproducibility of the system. The first section lists the results for a wool top that was used for calibration purposes. From the measured diameter characteristics the average fibre linear density of this wool sample can be independently determined as the density of wool is known. Using this value in Equation 1 yields the value of a shown in the table. Thus it is estimated that this Sirolan-Laserscan instrument registers only 40.1% of the available snippets. (It has been shown previously (Naylor, unpublished) that for a given instrument, alpha is approximately constant over a broad range of fibre fineness values.)

Whether or not a particular snippet is 'seen' or not by the Sirolan-Laserscan can be thought of statistically as a random event and Poisson counting statistics should apply. In the present case N is approximately 20,000 giving an expected standard deviation of 0.7%. This is in good agreement with the observed experimental variability for both the wool and cotton samples in Table 1.

Table 1 also lists the results of repeated measurements on two cotton samples. This illustrates the precision of measurement with the standard deviation of the mean of five measurements being approximately 1%.

For the next set of experiments, cotton samples with known fibre linear densities and fibre maturity covering a broad range were used to test the proposed approach. Fortunately most of Gordon's well characterised samples (1994,1995) were available and formed the sample set. A summary of Gordon's data for the available samples is listed in Table 2. These maturity and linear density values were determined by the Shirley Fineness and Maturity Tester, a double compression airflow technique.

The linear density of all the samples available from Gordon was measured using the Sirolan-Laserscan approach and the results are summarised in Table 2 and Figure 2. It can be seen in Figure 2 that there is a good correlation between the different approaches.

Conclusion

Based on the results to date, the new approach of using the Sirolan-Laserscan in this new mode of operation looks promising as the basis of a new technique for measuring cotton fibre fineness.

Acknowledgments

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Table 1. Summary of Preliminary Results

Sample	Weight (mg)	Wool Calibration Mean Diameter (mm)	N	ALPHA
1	50.0	21.9	19738	0.398
2	50.0	22.0	19938	0.406
3	50.0	22.1	19432	0.399
4	50.0	22.0	19701	0.401
5	50.0	22.0	19674	0.400
			MEAN	0.401
			SD	0.003
			CV (%)	0.74
Cotton 7				
Sample	Weight (mg)		N	Linear Density (mtex)
1	16.0		21563	160
2	16.0		21219	163
3	16.0		20828	166
4	16.0		21096	164
5	16.0		21072	164
			MEAN	163
			SD	2
Cotton 13				
Sample	Weight (mg)		N	Linear Density (mtex)
2	18.0		22590	172
3	18.0		21753	179
4	17.5		21435	176
5	18.0		21741	179
			MEAN	177
			SD	3

Table 2. Summary of Results.

Stuart Gordon's Results			Laserscan Results
Sample No.	Maturity Ratio	Linear Density (mtex)	Linear Density (mtex)
7	0.88	141	163
8	1.02	183	206
10	1.00	175	187
USDA13	0.61	140	177
USDA14	0.79	134	160
USDA16	0.94	158	163
USDA19	0.95	249	257
USDA21	0.92	368	410
USDA22	1.00	359	404
24	0.95	163	190
32	0.99	178	200
36	0.81	163	178
42	0.98	169	202

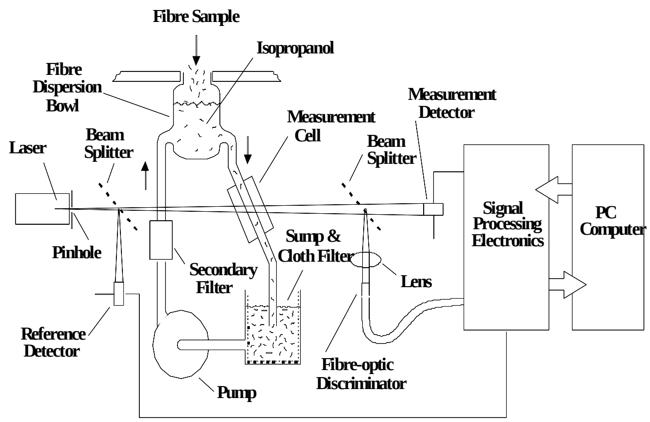

Figure 1. Schematic Diagram of Sirolan-Laserscan.

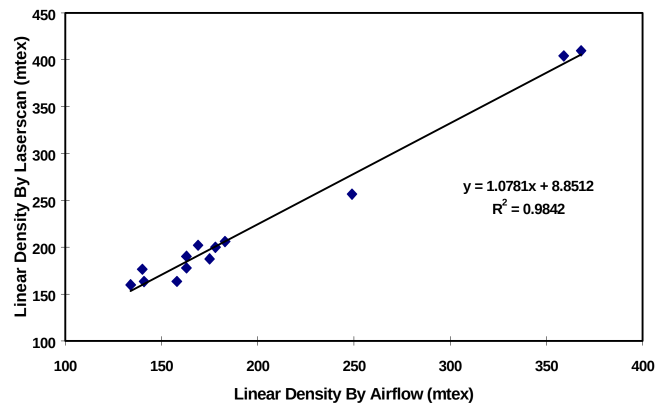

Figure 2. The relationship between the Linear density measured by the Sirolan-Laserscan and that measured previously by Gordon using a double compression Airflow technique.