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Overseas Visit Report: US Beltwide Conference and the USDA Southern Regional Research Center, January 1999

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1. Plain English Summary

The commonly used Micronaire value for cotton is related to both fibre fineness and maturity. There is a need for a new measurement technique to separate these. This is of particular importance to the Australian industry where varieties of fine, mature cotton have the potential to be wrongfully discounted commercially by misinterpreting a low Micronaire value as indicating immaturity in a coarser fibre.

A recent CRDC funded preliminary project (CRDC Project CSWT 1C) demonstrated that the Sirolan-Laserscan, in a novel mode of operation, is able to measure the fineness of cotton fibres independent of fibre maturity.

Following this successful preliminary study, the next stage in this research will be to undertake more exhaustive testing and trials of the approach and to examine (a) possibilities for also obtaining fibre maturity information using the Sirolan-Laserscan and (b) the scope for scaling up the technique from the laboratory to become a useful commercial measurement technique. Before embarking on this more major research phase, the current trip was designed to obtain an assessment of the commercial potential of the project. A paper on our preliminary results was presented to the US Beltwide meeting and also I visited and had in-depth discussions with the other key researchers in this area at the USDA in New Orleans. This was an ideal opportunity as cotton fibre quality is currently assessed commercially using the HVI system manufactured by Uster Zellweger in USA with significant input from the USDA.

The trip proved to be very successful.

As detailed in this report, it confirmed that current techniques for measuring fibre fineness and maturity are inadequate to say the least. Further, it is clear that there is a commercial need for these measurements as these aspects of fibre quality impinge on processing performance and end product quality.

The new approach developed at CSIRO received a very positive response both from the participants at the Beltwide meeting and from the researchers at the USDA laboratory in New Orleans. The main outcome of this trip is that there is general agreement that the new Sirolan-Laserscan approach has significant potential as a viable technique for measuring cotton fibre fineness. Further, it is thought that it might easily be possible to extend the approach to yield fibre maturity information by combining the results from this approach with the current micronaire measurement.

It was agreed that to progress this avenue of research it would be mutually beneficial for CSIRO and the USDA groups to work collaboratively. CSIRO has a potentially interesting new measurement technique and the USDA have a wealth of experience in cotton testing and ready access to cottons, other cotton measurement techniques as well as influence and links to the major cotton testing instrument manufacturer. This collaboration has already commenced informally with us already beginning to test some cotton samples that have been well characterised by the USDA groups. It is also proposed to set up a formal written collaborative agreement between the two organisations.

The report also details other interesting information that was gained from the meeting and visit.

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2. Background

Cotton fineness (linear density) and maturity are key quality parameters for cotton. They are important to both processing performance and end product characteristics. Unfortunately current commercial methods of assessing these parameters are inaccurate. The Micronaire value is a mixture of both fibre fineness and maturity. 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. This is of particular importance to the Australian industry where varieties of fine, mature cotton have the potential to be wrongfully discounted commercially by misinterpreting a low Micronaire value as indicating immaturity in a coarser fibre.

A recent CRDC funded preliminary project (CRDC Project CSWT 1C) demonstrated that the Sirolan-Laserscan, in a novel mode of operation, is able to measure the fineness of cotton fibres independent of fibre maturity.

Following this successful preliminary study, the next stage in this line of research will be to undertake more exhaustive testing and trials of the approach and to examine (a) possibilities for also obtaining fibre maturity information using the Sirolan-Laserscan and (b), the scope for scaling up the technique from the laboratory to become a useful commercial measurement technique. Cotton fibre quality is currently assessed commercially using the HVI system manufactured by Uster Zellweger in USA with significant input from the USDA. Compatibility with this system would be a major advantage for any new fibre quality test, ie could the new approaches being developed at CSIRO Wool Technology be easily incorporated into the HVI system? The Beltwide fibre quality conference provided an ideal opportunity to obtain an answer to this question.

Further, due to the geographical proximity of the conference to the USDA Southern Regional Research Center (SRRC) in New Orleans, it is proposed to also visit there. The SRRC is the centre of the world's research on cotton fibre fineness and maturity and has the only two research groups in the world currently working in this area.

In summary, attendance at this conference and the associated visit was designed to gather valuable information for assessing both the technical and commercial potential of the Sirolan-Laserscan approach to add value to the Australian cotton clip. This opportunity is timely, coming at the end of a successful preliminary study and before embarking on further research on this topic.

3. The Beltwide Meeting

3.1 General

The Beltwide Conferences are a series of sessions in parallel (each called a separate conference), over a four day period. This is an annual meeting organised by the National Cotton Council of America rotating around different US cities every January. This year the conference was held in Orlando, Florida.

The conference is focussed primarily on the needs of US cotton producers and the 4000 participants were predominantly US farmers. The first two days were entirely focussed on

'on-farm issues' and the fibre quality, textile processing sessions/conferences ran during the last two days. These sessions were notably much smaller than the main general sessions with attendances of 50 to100.

The full conference proceedings are published both in hard copy and on a searchable CD-rom. (The CD-rom will also contain abstracts from the last 10 years conferences.) I have ordered both the hard copy and CD-rom which will both be available in the Division's library.

The following notes of the conference highlight the main points, from my perspective, from the sessions that I was able to attend.

The general sessions were marked by a sombre feeling since the 1998 US growing season was characterised by 'uncooperative weather' and falling cotton prices. The NY Stock Exchange contract price had fallen to 60c/lb which was considered to be below the cost of production for US cotton.

The major competitor for cotton is polyester and Mark Lange from the National Cotton Council (US) noted that bulk polyester is now 28c/lb in Asia. Further, China is becoming a net exporter of cotton, putting further downward pressure on cotton prices.

Robert Fraley from Monsanto had a more optimistic view of the longer term market demand for cotton with a prediction for an upturn in world demand for textiles. Monsanto believes that this increased demand will be met through biotechnology! Up until now, Monsanto has focussed its biotechnology on 'on-farm issues' (eg 'Round-up' ready cotton), but feels that biotechnology in the near future will lead to cotton with improved fibre properties.

William Dunavant, a significant commercial trader, gave his annual view of the market, confirming a fairly pessimistic short term outlook. He noted:

- The quality of the current US crop is poor
- US cotton is not competitive on the world market
- A US federal subsidy for cotton growers (Step2?) has finished
- Australia is the only country that is doing well out of growing cotton at the moment.
- Import of cotton to the US is mostly due to quality requirements rather than price.

The Cotton Inc talk by J. Berrye Worsham noted that their advertising reached 92% of Americans 19 times per year. They are expanding their efforts into non-wovens with an emphasis on absorbent materials and also carpets. His talk was neatly summarised by his concluding remark: 'Cotton Inc' will continue to work hard for better times in the future.

Warlick from Parkdale Spinning Mills gave a spinners perspective. His two main points were

- fibre quality: he wants a 'man made' cotton, ie cotton with fibre quality that is both high and consistent.
- Cotton is still too expensive: The pressure is on to reduce the price of cotton. 60-70% of the spinners cost is in the raw material. In the last 10 years, the selling price for 18's single open spun yarn has decreased from $1.50 /lb to $0.65/Lb and is still falling!

A talk by John Maguire of the National Cotton Council highlighted the lobbying that the NCC do in Washington. A new congress was about to start and John gave details of the

make up of the new congress with particular emphasis on the likelihood of the congress to be sympathetic in developing farm policy and the scope for successful lobbying.

3.2 The Fiber Quality Conference

In this session/conference, 40 papers were presented over two days. The main areas covered were:

- Colour grading and trash measurement
- Differences between HVI and AFIS measurements in general
- Fibre maturity (7 papers)
- Measuring stickiness in cotton
- Conditioning systems for testing.
- The need for an improved nep measurement

Some specific points of note were:

- Colour grading: Current agreement between subjective classer assessment and the HVI is only about 70%. Duckett (U of TN) and Zellweger are working on new instrumentation - (seemed that classers assessments were influenced by other parameters eg trash content and 'yellow spot' – perhaps some similarities with the Wool Style measurement.)
- Short Fiber Content: There is a need for a new reliable HVI (ie fast) test. The current AFIS short fibre content does not correlate well with the HVI length uniformity. (Tyson, National Textiles)
- Zellweger are introducing an on-line control process for ginning and are claiming a significant improvement in fibre properties eg improved fibre length. Most of the improvements are believed to be due to better fibre moisture measurement removing the tendency for over drying.
- Hunter from CSIR in South Africa gave an general/broad overview of CSIR's work mentioning dyeing and flammability of wool/cotton blends.
- Devron Thibodeaux (USDA) gave a paper on the good relationship between single fibre measurements using MANTIS and bundle tenacity. This work has been published in detail in J Cotton Science (available on the web at www.cotton.org) In a related paper (Wessinger), it was noted the bundle tenacity values are highly regain dependent including hysteresis effects, which has implications for the HVI breaking module.

3.3 Issues Relating to Fibre Fineness and Maturity

Several papers were presented on measurements of fibre fineness and maturity. Correlations between measurement from the different current methods are low and there is no acceptable direct method that can be used to calibrate other approaches. In summary, there appears to be no current satisfactory method for measuring either fineness or maturity. The main methods and problems are:

- HVI micronaire: This known to be a mixture of both fibre fineness and maturity and it is impossible to separate the two components from this measurement.
- Image Analysis of fibre cross-sections. This is the most direct approach but suffers from being very labour intensive such that typically only 500 fibres per sample are measured. Other significant technical problems are (a) the fuzzy ill-defined edge of the fibre in the light microscope leading to potential errors and subjectivity in the measurement of fibre perimeter and cross-sectional area, (b) the problem of touching/overlapping fibres which

can result in false measurements and (c) a lack of contrast making the lumen difficult and in some cases impossible to define. According to Xu (Uni of Texas) up to 50% of fibres can't be measured due to these technical issues.

- The Shirley Fineness and Maturity Tester: This is an indirect test method based on the airflow technique. The precision and accuracy of the instrument are questionable and some years ago it was considered to be not robust enough to be used in the HVI. (For example, Bel-Berger noted a considerable difference between the results of fibre circularity from two version of the instrument.)
- The AFIS: This is based on individualising cotton fibres in an airstream and then the measurement is based on light scattering. The results from the AFIS do not agree well with other approaches and some believe that the fibre individualisation process results in a biased sample.
- NIR: This is an indirect method which relies on a calibration against another acceptable technique. It has advantages for HVI testing as it can sample quite a large sample (80g). It was trialed previously in HVI testing but was withdrawn.

In contrast to this measurement issue, several papers were presented trying to link fibre fineness and maturity measurements to textile processing performance. For example Hequet from the International Textile Center at Lubbock was looking for correlations between yarn properties and fibre fineness. His main finding was that the correlation depended primarily on which fibre fineness measurement technique he used! This is another pointer that the measurement issue needs a solution. Papers on fibre property measurements related to ginning (Davidonis and Bel-Berger from the USDA) were also limited by the imprecise nature of the current fibre measurement tools.

Prediction of yarn tensile parameters from current HVI data gives low correlations. This is an important textile problem and I suspect this could easily be due the fact that the miconaire value does not enable the number of fibres in the yarn cross-section to be accurately determined due to the ambiguity of fibre fineness vs maturity. (Theoretically it is known that the number of fibres in the cross-section is a key determinant of yarn properties.)

3.4 Response to My Paper on Measuring Fibre Fineness

My paper on measuring fibre fineness was well received. From the previous discussion there is a clear and agreed need for a new approach to the important problem of measuring fibre fineness and maturity. The strengths of the novel Sirolan-Laserscan approach were seen to be:

- A new approach
- A simple direct measurement of fibre fineness that is easy to understand and interpret
- The ability to measure a large number of fibres – in the paper I used a sample size of 20,000. (This is apparently important due to variability in cotton samples.)

The industry is currently 'groping in the dark' with this issue. A new technique which is able to deliver absolute results would be a major step forward. Even if it was not suitable for HVI testing (needs to be simple, rapid and robust), a technique that could be used for calibrating other indirect approaches is desperately needed.

Overall ,I was encouraged to continue to pursue this work.

4. The USDA Southern Regional Research Center

Following the Beltwide I spent a very useful two days visiting the USDA Southern Regional Research Center (SRRC) in New Orleans. The SRRC is one of four major facilities that form the Agricultural Research Service (ARS) of the US Department of Agriculture. The Center's research program is divided into five areras:

- Cotton quality and textile chemistry and engineering
- Food processing and sensory quality and food safety
- Commodity uses and environmental science
- Sugercane productivity research
- Termite research

In addition to in-depth discussions on my work and fibre quality measurement problems for cotton, on the second morning I gave a general talk about CSIRO DWT and my work and had brief discussions with other cotton researchers at the SRRC.

4.1 General Discussions

The cotton work is divided into three groups: cotton quality, textile engineering and textile chemistry. Each group is run by a research leader who appears to have a lot of autonomy in distributing the research dollars within the group. Equally, the individual research team leaders (teams appear to be quite small typically a senior scientist and one technician or student) seem to have a lot of freedom in choosing research topics.

Al French is the leader of the fibre quality group. He is very active in his own individual research which is very theoretical force field and quantum mechanical calculations related to understanding the molecular structure of sugars.

Skip Gallagher, a synthetic chemist is interested in coating fibres for fire retardency. He believes that there is a need for a new durable finish in this area, particularly for children's wear and also for the forces. His work is concentrating on siloxaines and various softening agents.

Tyrone Vigo, originally an organic chemist, is now in the area of fabric finishing. He has recently published a textbook on 'Preparation, Dyeing, Finishing and Performance' . His current research activities include antibacterial agents for cotton and cotton blend fabrics and a holist approach to fibers with multifunctional properties. He gave me a few of his papers.

4.2 Fibre Fineness and Maturity Research

Patti Bel-Berger is interested in using fibre maturity measurements in her research in ginning. She had some interesting fabric samples where she had identified that white undyed specks in the fabric are due to immature fibres. Patti is currently working on a project in Australia looking at the effect of ginning parameters on the problem of the white specks on fabric (undyed, immature fibres). It is clear that a robust measure of fibre maturity would be of great help to her. She would be delighted to collaborate and gave me various samples to measure.

There are two groups at the SRRC working on the measurement of fibre fineness and maturity. Devron Thibodeaux, a physicist by training, is focussing on detailed image analysis to hopefully give some calibration cottons. He does however have considerable technical problems (as listed above). Joe Montalvo, a chemist/spectroscopist is focussing on using NIR but is frustrated by not having a satisfactory way of calibrating his approach. Both agree that new approaches are needed and we had very fruitful in-depth discussions and it is clear that an ongoing collaboration could be most beneficial for both parties. As a starting point for further interactions, I brought back to Australia some cotton samples to measure with the new Sirolan-Laserscan approach. These particular samples have been well characterised using the exisitng techniques. Following these preliminary tests Joe Montalvo suggested that we set up a formal agreement between the two organisations to collaborate on the measurement of fibre fineness and maturity.

5. Appendix: Copy of Paper Presented at the Beltwide Conference

Appendix

Presented at the Beltwide Cotton Quality Measurement Conference, Orlando, January 1999.

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 μm with differences of 0.1 μm being significant commercially.

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, α, was then applied to yield the total fibre snippets in the sample. The average fineness (linear density) F was then calculated by the formula:

$$F = \alpha W/(NL)$$

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 α 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

Wool Calibration Sample	Weight (mg)	Mean Diameter (μm)	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

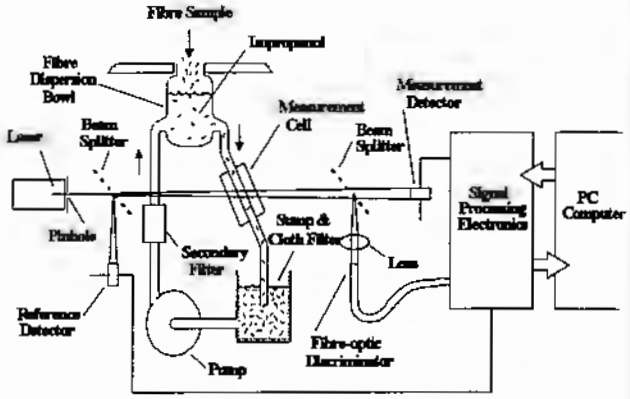

Figure 1. Schematic Diagram of Sirolan-Laserscan.

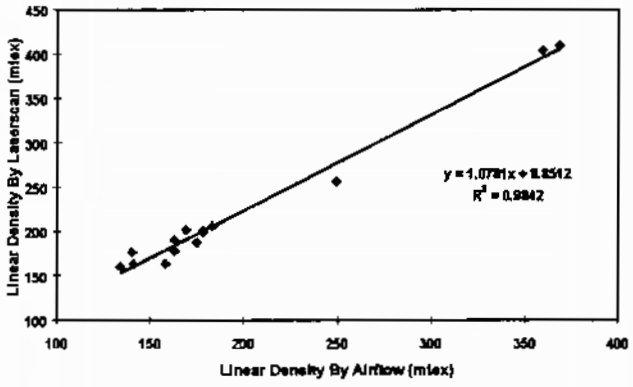

Figure 2. The relationship between the Linear density measured by the Sirolan-Laserscan and that measured previously by Gordon using a double compression Airflow technique.