

REPORTS

Part 1 - Summary Details

Please use your TAB key to complete Parts 1 & 2.

CRDC Project Number: CTFT2C

Annual Report: ☐ Due 30-September

Progress Report: ☐ Due 31-January

Final Report: ☒ Due 30-September

(or within 3 months of completion of project)

Project Title: Cotton Fineness and Maturity Measurement using the Sirolan-Laserscan

Project Commencement Date: 1/1/2002 **Project Completion Date:** 30/6/2003

Research Program: 6 Value Chain

Part 2 – Contact Details

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Background

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 the previous project, CWT4C, a new approach to measuring cotton fibre fineness and maturity independently using the Sirolan-Laserscan in a novel mode of operation was investigated and developed. The project proved to be quite successful. For example Geoff Naylor, the principal researcher in the project presented a paper at the US Beltwide Fibre Quality and Textile Conference in January 2001 in Los Angeles. The paper was well received and an outcome of this presentation is that the author has been invited to become a member of the ITMF working party on fibre maturity.

The major outcome of CWT4C was a clear validation of the measurement principle adopted in the so-called Laserscan approach. The simple steps in this procedure are:

- (a) preparation of snippets of cotton each of known length (This is done simply using a guillotine)
- (b) weighing a quantity of snippets
- (c) counting the number of snippets using the Laserscan as the counter
- (d) calculating directly the average fibre fineness (linear density) as the weight per unit length
- (e) inferring the fibre maturity from the average fibre fineness and the micronaire value using the so-called Lord equation.

This validation work included working closely with Dr Greg Constable at ACRI who kindly provided key sets of cottons for the validation trials.

One of the difficulties with the Laserscan approach was the speed of measurement. In the early experiments one measurement typically took 45 minutes. This was reduced to about 10 minutes, but this still falls well outside the 30 second target as demanded by the current HVI system.

Another valuable outcome from the work was the feedback and encouragement that the measurement was seen as being of great potential value to the cotton industry. This very positive feedback was forthcoming from Dr Greg Constable and also from key US researchers at the US Beltwide research meeting.

General aims of the project

The overall aim of the 18 months extension project was to continue the work and progress obtained in CWT4C in order to develop a satisfactory and usable test method for determining cotton fineness and maturity using the Sirolan-Laserscan approach. Specifically there are three major aims.

The first aim was to simplify/speed up the measurement technique in order to make it compatible with the requirements of modern HVI instrumentation.

The second major aim of this project was to demonstrate and convince the international community of the accuracy and usefulness of the new measurement.

This is a key stepping stone to its acceptance internationally by the traders and mills who purchase Australian cotton.

The final aim of the project was to develop and build a cotton-specific prototype of the required instrumentation. (The apparatus used in CWT4C was based around the Sirolan-Laserscan which has many features that are not needed for the current application.) It was envisaged that this prototype would be used for demonstration to the trade, and in discussions with possible licensees of the technology eg instrument manufacturers.

List the project objectives and the extent to which these have been achieved.

Year1 (1/1/2002 to 30/6/2002).

(a) Initiation of comparative trials with key researchers at the USDA to demonstrate the validity of the approach to an international audience.

(b) To identify procedures for increasing the speed of the measurement with the aim of approaching that required by HVI instrumentation.

Year 2 (1/7/2002 to 30/6/2003)

(a) Completion of comparative trials with the USDA.

(b) Completion of the required reengineering resulting in a new prototype suitable for use in larger scale mill trials.

In the first year, as indicated in a previous progress report, it was decided to not to tackle the first objective. The project developed exciting new patented methodology for objective (b), and it was deemed important to keep this 'inhouse' until it was fully developed for IP reasons.

Objective (b) for both years were satisfactorily completed and a prototype instrument was installed at ACRI in June 2003 for field trials.

Summary of Technical Results and 'Take Home Messages'.

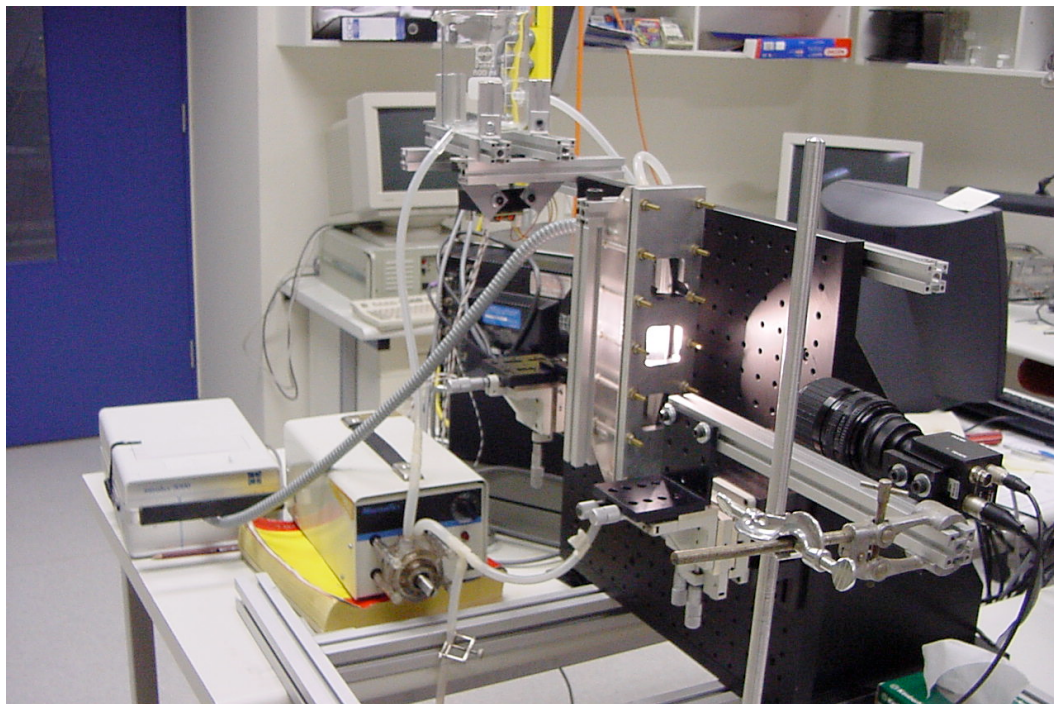
As stated above, a primary limitation of the Sirolan-Laserscan approach was its speed of operation. In the Sirolan-Laserscan the fibre snippets are transported through the instrument in a fluid suspension. They are 'counted' one by one as they pass an optical sensor (based on laser technology) in a specially designed optical cell. It was realised that counting one-by-one limited the speed of operation, and alternative processes were investigated. A significant breakthrough was the concept of using a camera system to capture an image of many fibres at once and then using modern computer image analysis procedures to count and measure the length of the fibre snippets in the image. Various systems for spreading out the fibres and transporting them to the measurement zone were tested (and are covered in the provisional patent). The final design maintains a fluid suspension system and specialised optics (dark-field illumination) to improve the contrast.

Other important features that evolved were:

- (a) A water based system rather than the solvent used in the Sirolan-Laserscan. (This was done for both OHS&E and also cost considerations.)
- (b) In the water system a suitable wetting agent was required so that the fibre snippets didn't simply float on the surface but entered into the suspension. This proved quite a challenge, however a suitable detergent was identified that didn't have any undesirable characteristics (eg solution had to remain transparent).
- (c) The computer image analysis was able to measure the length of individual snippets as well as counting them and so it was no longer necessary to assume all had the exact same length.
- (d) The concept of not measuring all the snippets but rather just a proportion was developed. This gave scope for further enhancement of the instrument speed.
- (e) A tapered cell so that the concentration of snippets in the image can be adjusted by the position of the camera relative to the taper ie low at the thin end and higher at the thick end.
- (f) A 'smart' system that is capable of choosing the optimal position along the tapered cell for rapid measurement.

Figure 1 illustrates the working laboratory instrument after about 12 months of development of these ideas and successful laboratory testing.

Figure 1. Early working laboratory instrument.



At this point it was decided to move to designing and building a self contained prototype instrument. Criteria were developed for the prototype, with some of the key requirements being:

- (a) Instrument to cost no more than \$15,000 to build. (This figure was derived from an expected final sale price of \$60,000 which was considered viable in the marketplace and similar to other instruments eg the FMT.)
- (b) An instrument speed of 2 minutes per sample for the prototype with clear provision for reduction to 30 seconds in later refinements.
- (c) Computer controlled, and easy to operate.

Given the available resources and time the task of automating sample preparation was excluded from the prototype requirements.

The resultant design and instrument now called 'Cottonscan' is shown in Figures 2 (in Geelong) and at ACRI in Figure 3 installed at ACRI in June 2003. Note that in the new design the instrument has moved away considerably from the Sirolan-Laserscan and indeed does not contain any of the Sirolan-Laserscan IP. (This is fortuitous as this avoids any requirement for obtaining a licence to use IP developed for the wool industry.) Further the new prototype instrument contains a range of new IP and indeed a provisional patent has been prepared and lodged to cover this. Hence the name change for the prototype instrument.

Figure 2. The prototype Cottonscan instrument in Geelong shortly after manufacture.

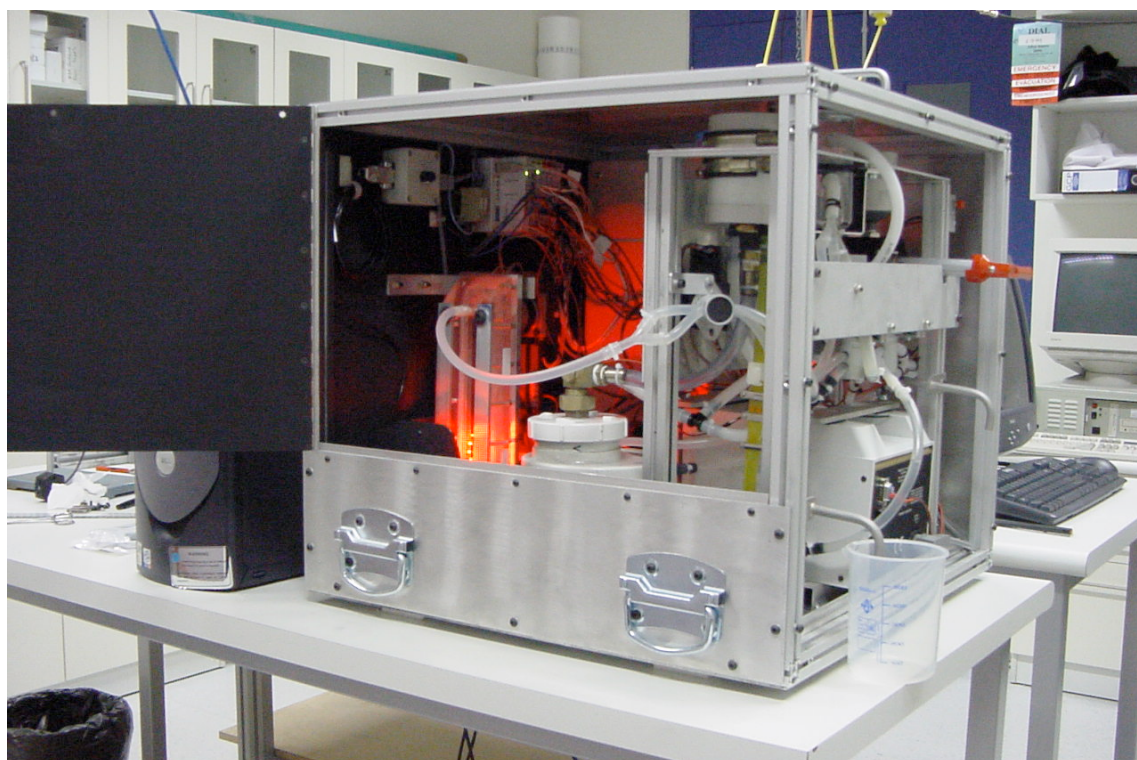
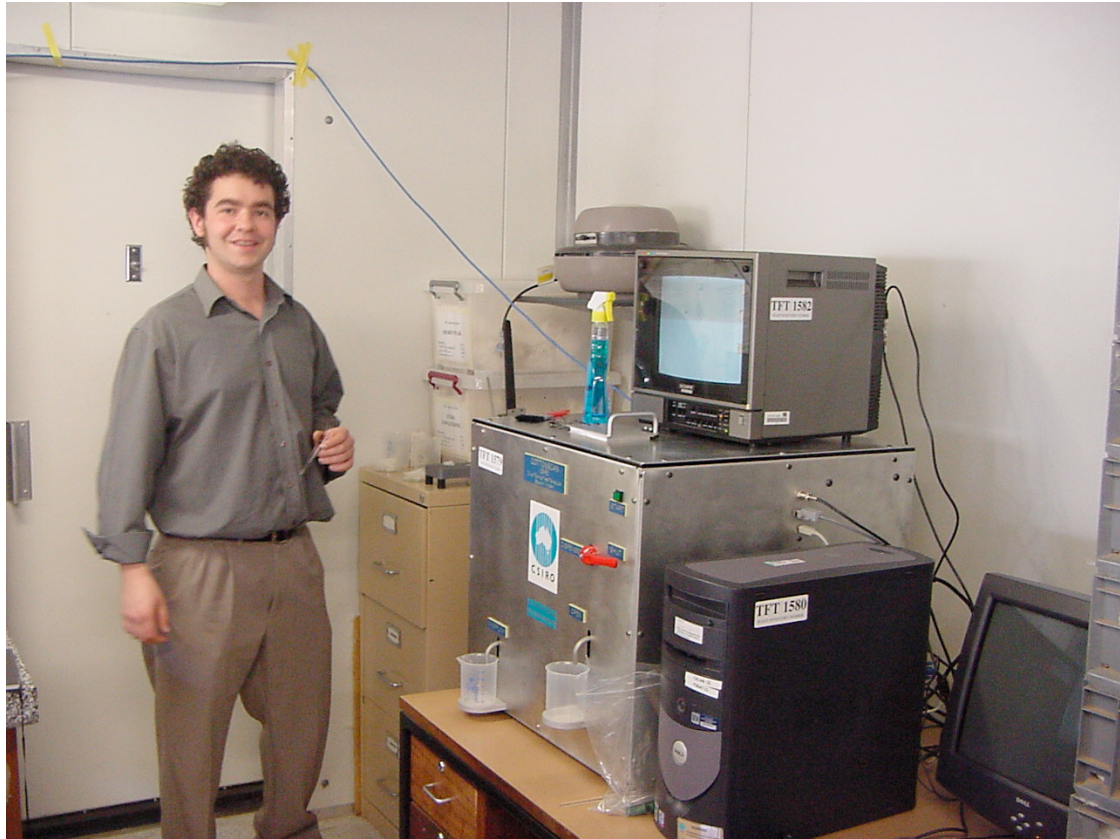


Figure 3. The Cottonscan instrument installed at ACRI.



In the prototype instrument a sample of snippets of approximately 15mg are prepared manually and entered into the instrument. (This is typically about 25,000 snippets and is about 4 times the amount of cotton used in the HVI length and strength test.) The working part of the instrument has a known and fixed fluid volume (approx. 400mls). The instrument automatically stirs and forms a uniform suspension of snippets and the suspension is actively pumped and recirculated through the measurement zone/cell. The volume of fluid captured in one frame of the camera is known and the instrument measures the length of snippets in the frame. From a simple ratio it then estimates the total length of snippets in the sample and hence the average fibre fineness. The instruments proceeds and measures for a fixed number of frames (typically 50 to 500) or it can be operated in 'smart' mode whereby it will continue to collect frames until a required precision is achieved. At the end of the measurement, the sample is dumped into a sump and the instrument automatically cleans itself in preparation for the next measurement.

Some technical challenges that required extensive development/testing were:

- (a) Development of suitable procedures and calibration curves so that the occurrence of overlapping snippets does not lead to a false result. (This effect has been modelled and increases as the concentration of snippets increases.)
- (b) Cross contamination from a previous sample can occur if the self cleaning system is not adequate. Considerable effort has been expended on this including designing the fluid circulation system with this in mind and also the introduction of a 'flush' system around the inside edge of the glass receptacle.
- (c) In the longer term ie after many measurements, small clumps of fibres can coagulate and stick in the flow system and lead to contamination. Experience shows that this is a rare event however an operational protocol for detecting this has been developed (including regularly measuring a blanks). Further the system includes a manual extra strong flushing system should this occur.
- (d) Bubbles can lead to false readings. Again the fluid circulation system has been optimised to reduce the occurrence of bubbles.
- (e) The instrument relies on a uniform suspension. This requires adequate stirring. This has been tested. For example, a careful analysis looking for any trends in length of snippets per frame during the course of the measurement was used as one determinant of this. The measured variation between frames was shown to be at the same level as expected from natural random variations and no drift was observed.
- (f) Long term stability of the instrument was checked. A set of reference samples were chosen and a protocol developed for running them daily to check the instrument. No long term drift has been observed.

Figures 4 to 7 show some results. In Figures 4 and 5, the USDA micronaire calibration set has been measured and the results compared with the values obtained by a US researcher using a carefully calibrated and FMT. The agreement is very pleasing. Figures 6 and 7 illustrate some results from earlier testing of the system.

Figure 4. Comparison of the Cottonscan average fibre fineness values as a function the assigned values obtained from an FMT.

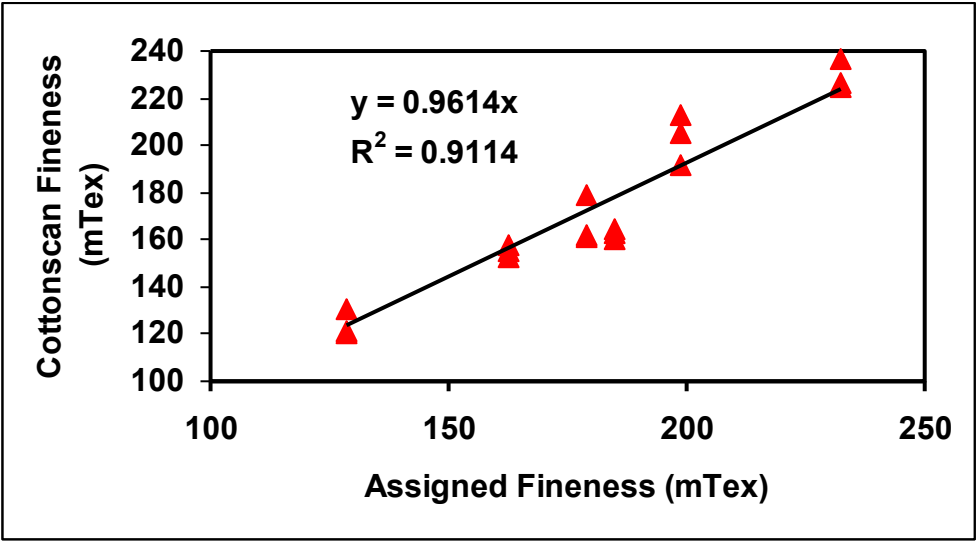


Figure 5. Comparison of the Cottonscan average fibre maturity values as a function the assigned values obtained from an FMT.

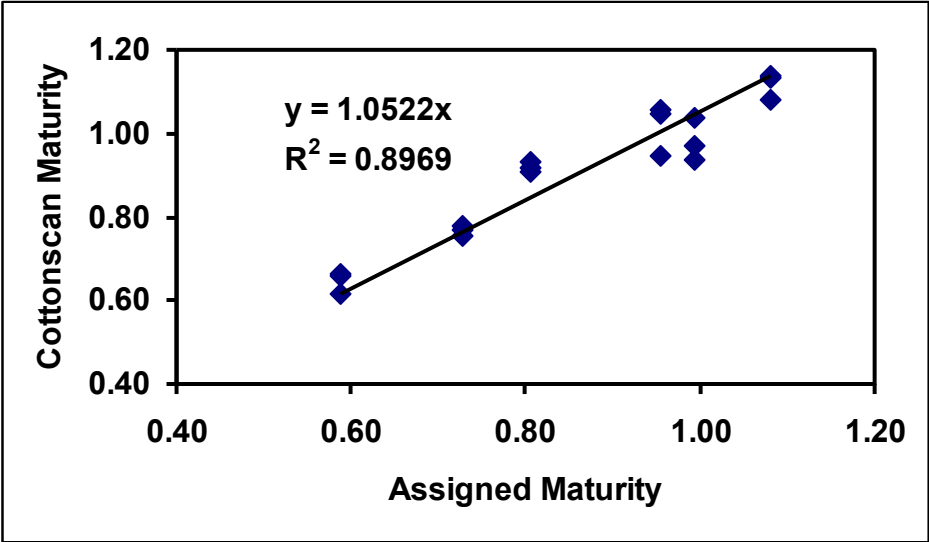


Figure 6. Some results of testing Cottonscan (a) illustrating that the number of measured pixels ie the length of fibre measured by the instrument increases as the concentration of fibres in sample increases and (b) the system is stable over time (the diamonds and squares represent measurements separated by about one month).

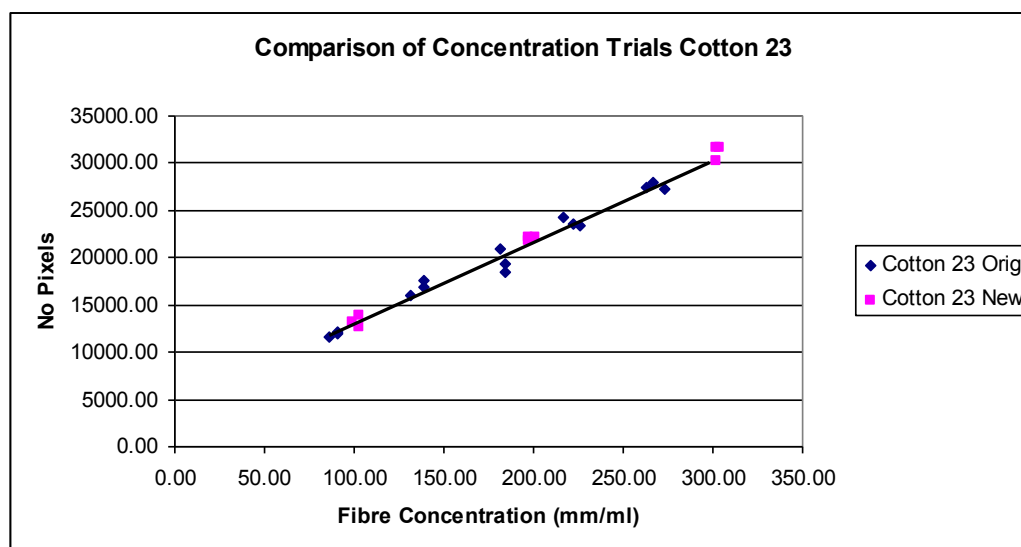
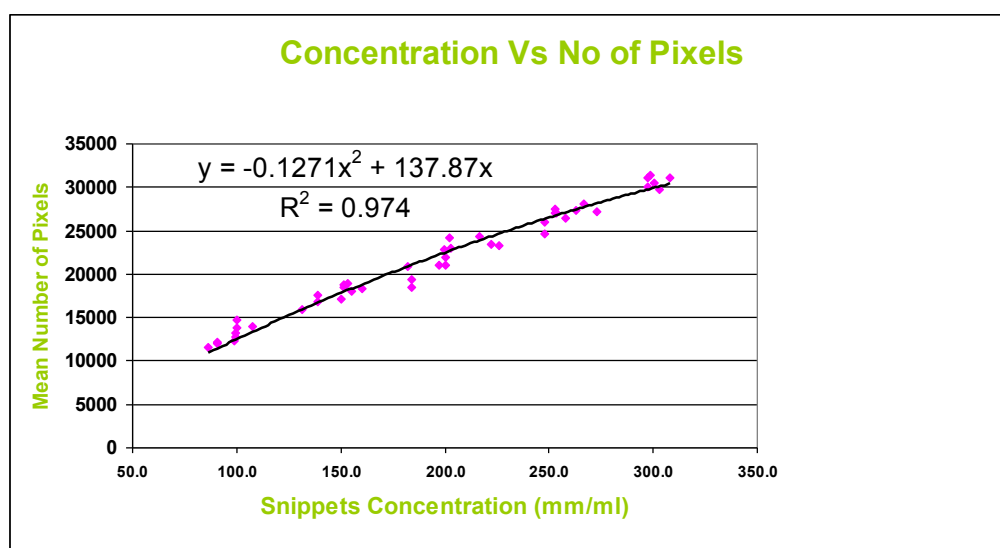


Figure 7. Development of the detailed calibration curve for Cottonscan: Note the slight curve due to the increasing presence of overlapping fibre snippets as the concentration of snippets increases.



Following all the in-house testing at Geelong, the prototype instrument together with the computer and a simple operator's manual were transferred to ACRI in mid-June for field testing. No significant problems were encountered in this transfer ie the instrument is mechanically robust and stable, and the set of reference samples confirmed the operation of the instrument at its new location. Following a brief training period, the instrument was left in the capable hands of the ACRI staff for

trials. (These trials were conducted after the end of the period of this project and will be reported separately.)

Intellectual Property

As noted above a provisional patent titled “Method and apparatus for testing fibres” covering all aspects of the ‘Cottonscan’ was lodged on 17th April 2003.

Plan for Future Activities

CRDC has agreed to fund ongoing work in this area (CTFT8C). The planned objectives for this work are outlined in detail in that project proposal.

List of Publications

G.R.S. Naylor ‘Progress at CSIRO’ Proceedings of the ITMF International Committee on Cotton Testing Methods, Working Group on Fibre Maturity, Bremen, 2002.

G.R.S. Naylor and M. Purmalis. ‘Metho and Apparatus for Testing Fibres’. Australian provisional patent lodged 17 April 2003.

Final Report Executive 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.

This project extends the work of a previous CRDC funded project (CWT 4C). The earlier project demonstrated that a new approach using an instrument called the Sirolan-Laserscan is able to measure the fineness of cotton fibres independent of fibre maturity. Further, using the experimentally measured fibre fineness value, a process for mathematically 'unravelling' the Micronaire value has been demonstrated leading to accurate fibre maturity values.

The current project aimed to simplify the instrument and increase its speed with a view to matching the speed of the current HVI systems.

A new prototype instrument was designed, built and tested. The results to date are positive. The computer controlled instrument can measure the fineness and maturity of cotton samples and is currently undergoing further testing.