COTTONSCOPE – RAPID, INDEPENDENT AND SIMULTANEOUS MEASUREMENT OF BOTH COTTON FIBER LINEAR DENSITY (FINENESS) AND MATURITY

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Abstract

A rapid, accurate way of measuring cotton maturity and linear density (fineness) has been sought by industry. CSIRO has developed separate techniques for rapid determination of fiber maturity, the Siromat™ technology, and linear density (fineness), The Cottonscan™ technology. The current paper introduces the Cottonscope instrument. This new commercial instrument combines both the Siromat™ and Cottonscan™ approaches into one instrument such that both fiber maturity and linear density (fineness) can be measured rapidly, independently and simultaneously. Results are presented for two well characterized sets of cotton samples and the results are in good agreement with previously published values.

Introduction

A rapid, accurate way of measuring cotton maturity and linear density (fineness) has been sought by industry for decades. Accurate measurements of these parameters would be a major breakthrough assisting all stages of the cotton processing pipeline, providing better quality control and optimization.

CSIRO has developed separate techniques for rapid determination of fiber maturity and linear density (fineness). The Siromat™ technology (Gordon and Phair, 2005), is based on the industry standard polarized light microscopy (PLM) Standard Test Method (ASTM D1442, 2000) to measure fiber maturity. This PLM method uses interference colors to identify the maturity of a cotton fiber. The Cottonscan™ technology determines fiber linear density (fineness) (Abbott et al, 2010, Abbott et al, 2011). It is based on the direct method of measuring the total length of a known mass of fiber snippets to calculate directly mass per unit length. It uses an aqueous medium to transport the fiber snippets past a measurement cell such that snippets are imaged and the total snippet length in the frame is extracted using modern image analysis techniques.

Last year a prior version of Cottonscope was described (Brims and Hwang, 2010). This instrument was a commercial version of the Siromat™ technology. It was based on cotton snippets spread on to a glass slide with the snippets then being examined using polarized light microscopy to determine the maturity distribution of fibers within the sample. A typical sample size was 8 mg.

The current paper introduces a new version of the Cottonscope instrument (Cottonscope II). The new instrument combines both the Siromat™ and Cottonscan™ approaches into one instrument such that both fiber maturity and linear density (fineness) can be measured rapidly, independently and simultaneously.

Materials and Methods

Two different sets of samples were chosen to evaluate the technical performance of the new Cottonscope instrument. Hequet et al (2006) developed a set of reference samples for fiber maturity based on extensive analysis of a large number of individual cross-sections of embedded fibers per sample. A subset of 22 from this reference set was used to evaluate the fiber maturity aspects of the instrument. This subset was chosen to cover a wide range of average maturity values. To evaluate fiber linear density (fineness) a set of samples that has previously been well studied in the Cottonscan™ were chosen (Abbott et al 2011).

Results and Discussion

Figure 1 shows a picture of the Cottonscope instrument. It is a fully automated microscope that captures color images of cotton snippets in water. The sample size is approximately 50 mg (increased from the 8 mg in the prior version of Cottonscope). The distribution of maturity ratio and also the average fiber linear density (fineness) are measured in approximately 25 seconds. The instrument is small and portable weighing 6kg. (Further technical information and a video of the operation of the instrument are available online at www.cottonscope.com)

Figure 1. Cottonscope water based measurement system.

Snippets approximately 0.7mm or shorter are prepared using a custom guillotine with a 0.7mm thick blade as shown in Figure 2. The snippets fall onto a collection trough and weighed. The fibers are manually transferred to the Cottonscope.

Figure 2. The custom 0.7 mm guillotine mounted above the snippet weighing balance. The image shows the underside of guillotine slot and collection trough on the balance.

In the Cottonscope, the microscope lens tube is permanently submerged in water and a two LED light source is used. The two LEDs are red and green, the green LED is polarized and the red LED is not polarized and the two beams are combined by a beam splitter. The new light source allows a greater depth of field than in the prior Cottonscope and a simpler and more linear distinction of the mature fiber colors. The red and green light combines to illuminate the fibers in a yellow light. The fibers appear dark or translucent if immature and red if mature. The more red the fiber, the more mature it is. The light passes through the glass window at the base of the bowl, through the water medium and up the water tight tube containing the lens to the color digital camera. The fibers are conveyed passed the optical path via a rotating water stirrer. The water stirrer is not in contact with the base of the bowl and is rotated via a magnetic link, this enables the bowl to be completely drained and rinsed of fibers at the end of the measurement. Figure 3 shows a typical image.

Figure 3. Typical Cottonscope image of cotton snippets.

Figure 4 shows the maturity results obtained using the subset of 22 of the fiber maturity reference cottons. In this figure The Cottonscope data on the vertical axis is plotted against the published values for the reference cottons (Hequet et al, 2006). The agreement is very encouraging.

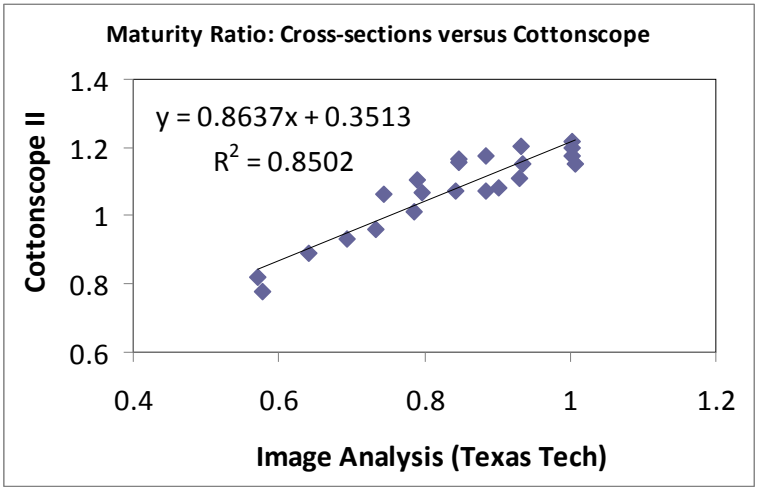

Figure 4. Average fiber maturity measured on the Cottonscope plotted against the published values (Hequet at el, 2006).

Figure 5 shows the average fiber linear density values for a set of well characterized samples plotted against published values determined from inter-laboratory trials using the Cottonscan technology (Abbott et al, 2011). Again the agreement is very encouraging.

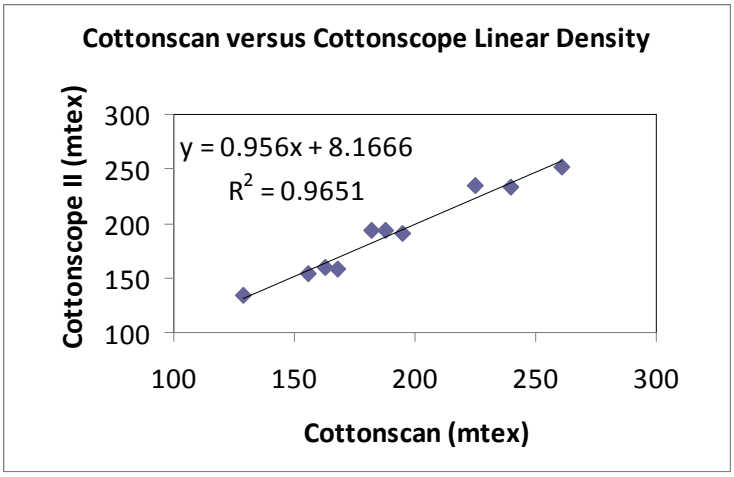

Figure 6. Average fiber linear density values measured on the Cottonscope plotted against the published values (Abbott et al, 2011)

Summary

The current paper introduces a new version of the Cottonscope instrument. The new instrument combines both the Siromat™ and Cottonscan™ approaches into one instrument such that both fiber maturity and linear density (fineness) can be measured rapidly, independently and simultaneously. The preliminary results that are reported are in good agreement with prior published data and confirm the suitability of Cottonscope as a useful instrument for rapid and accurate assessment of linear density (fineness) and maturity of cotton samples.

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