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UPDATE ON COTTONSCAN: AN INSTRUMENT FOR RAPID AND DIRECT MEASUREMENT OF FIBRE MATURITY AND FINENESS

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Abstract

The Cottonscan instrument for the rapid measurement of average fiber fineness and fiber maturity has been successfully re-engineered to improve its precision. Comparative trials have been conducted between three instruments. The observed 95% confidence limit for replicate measurements of average fiber fineness on a single instrument was ±6.5 mtex, and the mean between instrument differences were less than 4 mtex.

Introduction

The commonly used Micronaire value for cotton is related to both fiber fineness (weight per unit length) and fiber maturity (degree of fiber wall thickening). From the spinners' perspective, both fiber fineness and maturity are key parameters with separate effects on mill productivity and yarn quality. For example, yarn is specified in terms of its weight per unit length and fiber fineness (weight per unit length) determines the number of fibers in a given yarn cross section. The use of finer fibers increases the number of fibers in the cross section of a given yarn, which improves spinning efficiency and yarn evenness. Equally fiber maturity is also an important fiber quality parameter as immature fibers can degrade spinning performance and fabric quality e.g. evenness of dyeing due to the presence of neps.

Hence a technology for rapid and routine measurement of both fiber fineness and fiber maturity is desired by both cotton classers and the processing industry. One approach to this is the so-called Cottonscan instrument, illustrated in Figure 1 (Naylor 2001 and Gordon and Naylor 2004). The approach of this technology is to prepare a known mass of snippets for a test cotton and then measure the total length of the fibers in the sample so that the fiber fineness (mass per unit length) can be directly calculated. The total length is determined by forming a uniform suspension of the snippets in a liquid, which is passed though an optical cell where the snippets are photographed and examined using image analysis techniques. Further, combining this measurement with an independently measured Micronaire value (from a HVI) the average fiber maturity can be calculated using Lord's well established empirical relationship between Micronaire, maturity ratio and fineness (Lord, 1956). Further details of the first prototype Cottonscan instrument are described by Gordon and Naylor (2004) including some preliminary results. For example Figure 2 reproduced from Gordon and Naylor shows the good correlation between fiber fineness and maturity values obtained on the Cottonscan instrument with FMT measurements from six well blended cotton samples. (The FMT data were independently measured by Montalvo using his upgraded FMT system (Montalvo et al 2002).

Over the last twelve months the Cottonscan instrument has been re-engineered to improve the precision of the data and three working instruments are now in operation. These developments will be discussed in this paper.

Experimental

Six well blended cotton samples representing a range of fiber fineness and maturity samples were used for this study. For the original Cottonscan instrument sample snippets were prepared from aligned 'beards' of fibres produced using the SpinLab Fibroliner as described previously (Naylor and Sambell, 2001). For all measurements with the reengineered instrument, the six cotton samples were first processed into sliver form using the mini-processing line at USDA-SRRC. Sample snippets were then prepared using the standard double bladed Sirolan-Laserscan guillotine.

Results

(a) Single Instrument Precision

In Figure 2 the average Cotton fineness value determined from the Cottonscan instrument is plotted against the 'Nominal' values obtained by Montalvo (private communication) using his upgrade FMT instrument for a range of different samples. The scatter in the repeat measurements (n=5) in Figure 5 of individual samples is up to 20mtex. Investigation revealed that a major component of this between replicate variation in the linear density measurement was the precision of the measurement of the sample mass (typically only 15 mg). As a result the instrument was re-engineered to incorporate an enlarged sample mass (typically 100mg).

Figure 3 illustrates the results of measurements on the same set of cottons in sliver form with the reengineered instrument. In this case the between replicate variation has reduced significantly and the R-squared value of the regression also improved. Figure 4 shows the corresponding fiber maturity values obtained from the re-engineered Cottonscan instrument (inferred from an independent Micronaire measurement using Lord's equation).

(b) Between Instrument Precision

Two additional working prototypes of the improved Cottonscan were manufactured and comparative instruments trials were undertaken using the same six cottons, in sliver form. Six replicates were measured on each machine and the results are summarized graphically in Figure 5. Figure 6 shows the partial residuals from an analysis of variance (ANOVA) of this data taking account of the expected variation between samples. From this analysis the 95% confidence limit for replicate measurements of average fiber fineness on one instrument is ±6.5 mtex i.e. ±3% for a typical 200 mtex sample. This can be seen in Figure 6 for each instrument. It can also be seen in Figure 6 that the average difference between instruments is small and indeed less than the within instrument variation. From the analysis, the average between instrument differences was less than 4 mtex.

Conclusion

The Cottonscan instrument for the rapid measurement of average fiber fineness and fiber maturity has been successfully re-engineered to improve its precision and comparative trials have been conducted between three instruments. The observed 95% confidence limit for replicate measurements of average fiber fineness on a single instrument was ±6.5 mtex, and the between instrument variation was less than 4 mtex.

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Figure 1. The ‘Cottonscan’ instrument.

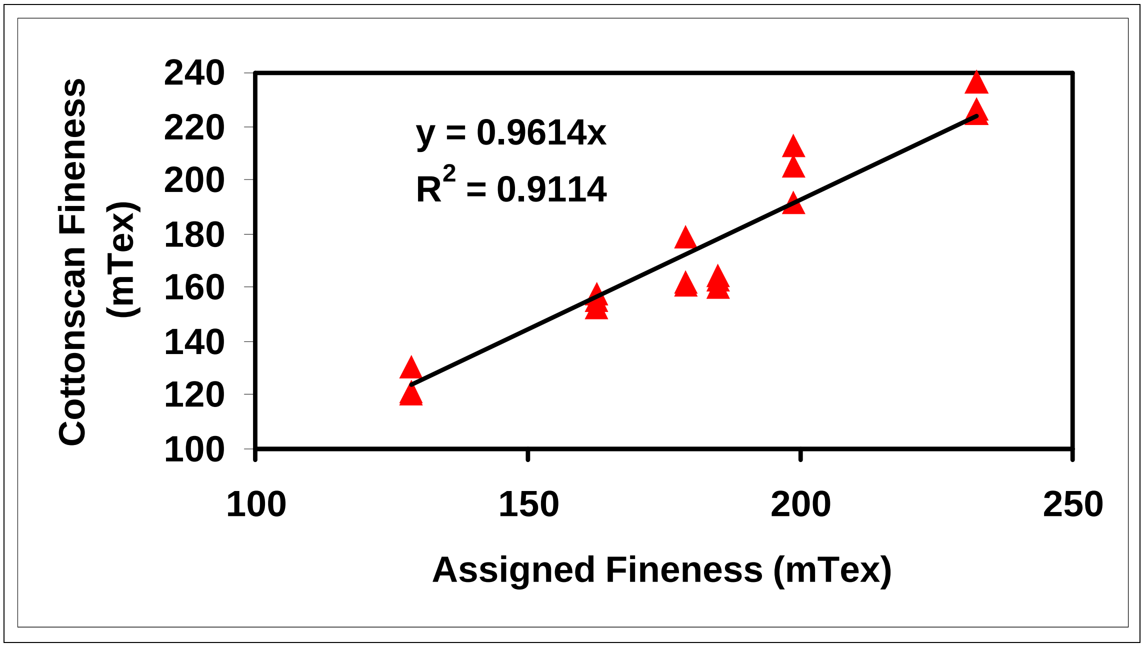

Figure 2. Original Cottonscan average fiber fineness data for six well blended cotton samples. (Reproduced from Gordon and Naylor, 2004)

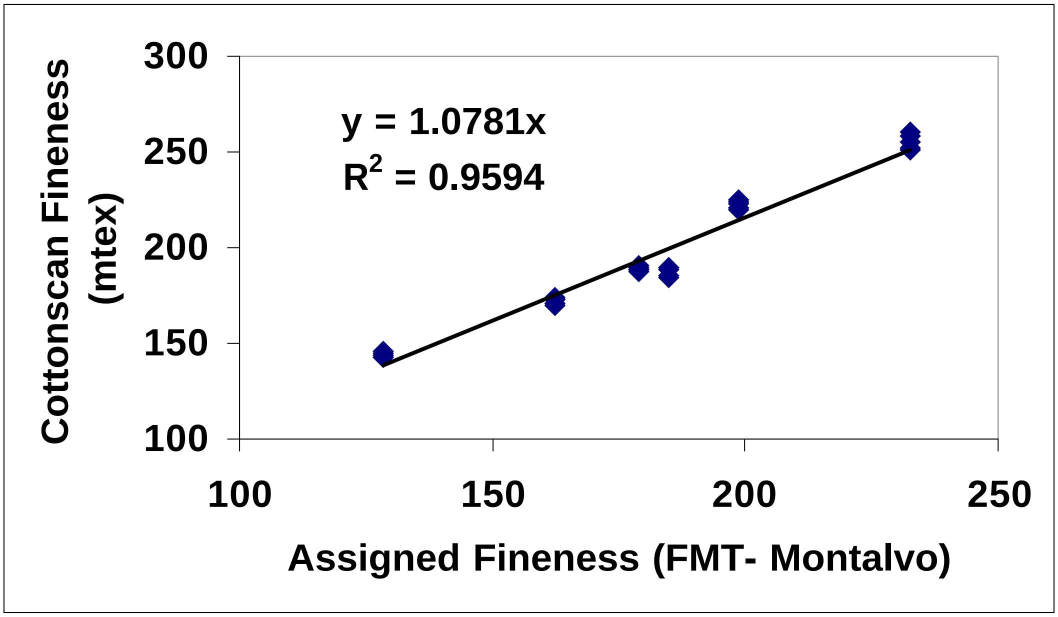

Figure 3. Average fiber fineness results from the Re-engineered Cottonscan instrument for the same samples as in Figure 2 (n=5).

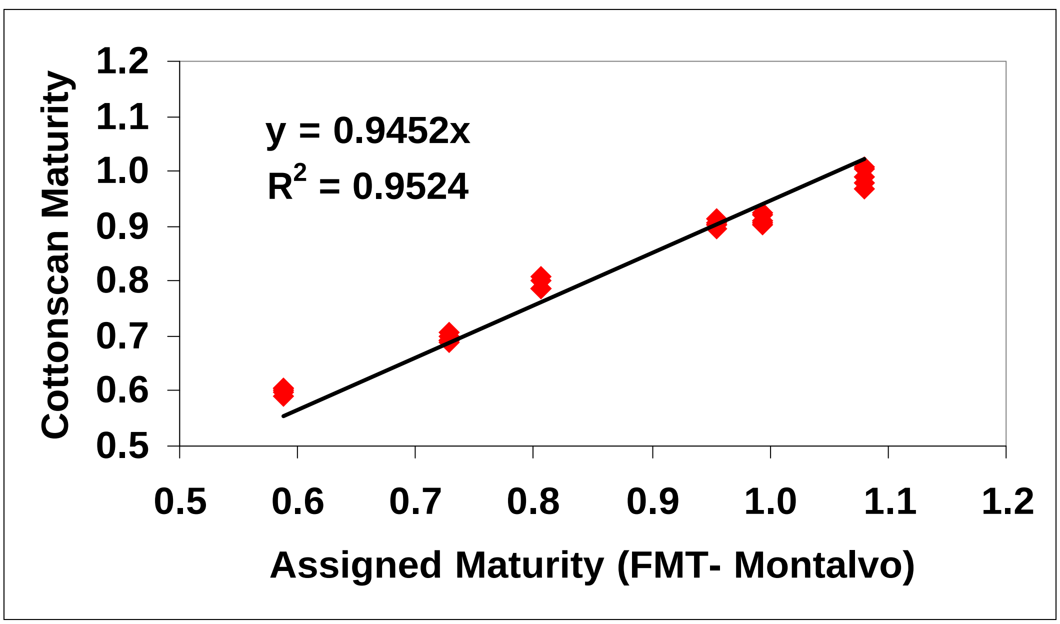

Figure 4. Complementary average fiber maturity results from the Re-engineered Cottonscan instrument (n= 5).

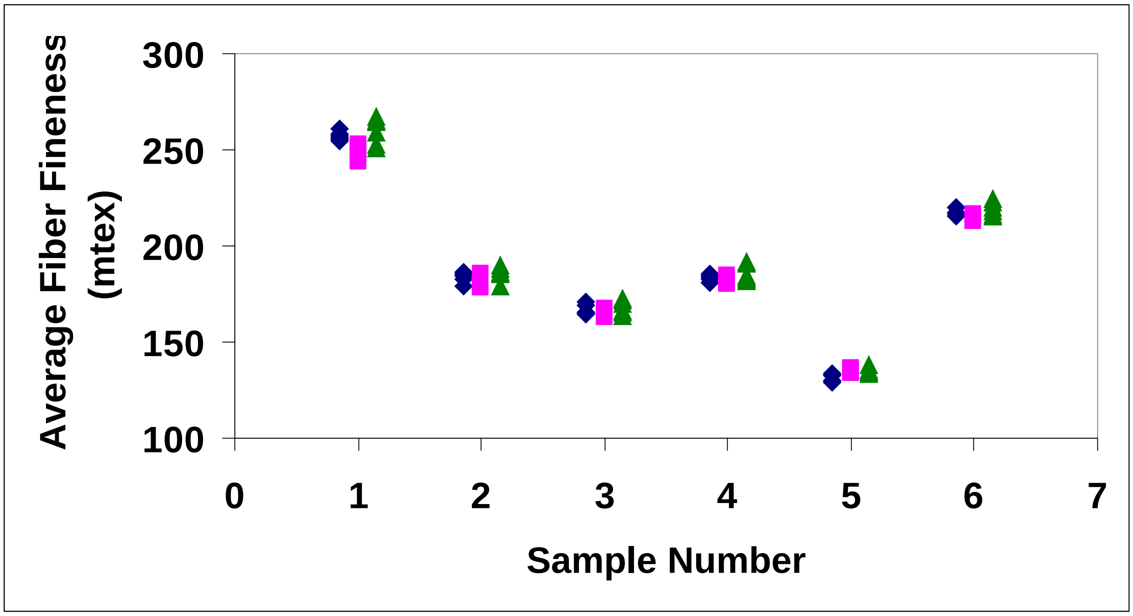

Figure 5. Individual results from comparative trails of three Cottonscan instruments. Each sample was measured six times in each instrument. (The three instruments are represented by different symbols.)

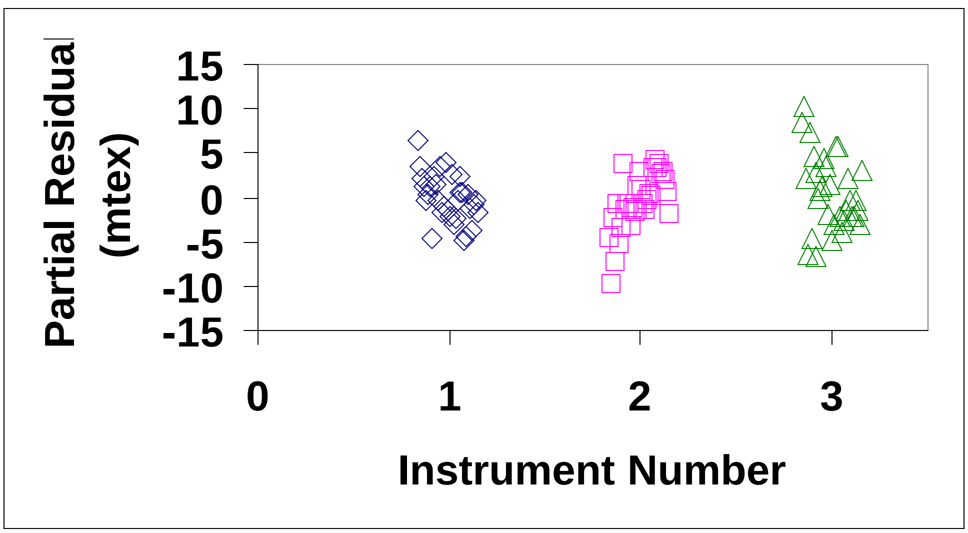

Figure 6. Partial residuals from an ANOVA of the data in Figure 6 taking account of the between sample variation.