

RAPID COTTON MATURITY AND FINENESS MEASUREMENTS USING THE COTTONSCOPE®

J. E. Rodgers
C. D. Delhom
USDA-ARS-SRRC
New Orleans, LA
D. P. Thibodeaux
USDA-ARS-CQRS
Clemson, SC

Abstract

Much interest has been shown in new and rapid measurements of fiber maturity and fineness. The Cottonscope is a new instrument for fiber maturity and fineness, using a longitudinal measurement of weighted fiber snippets in water by polarized light microscopy and image analysis. A program was implemented to determine the capabilities of the Cottonscope to measure cotton fiber maturity and fineness. The measurement takes less than 8 minutes per sample (6 measurements per sample) and is easy to perform. The major operational impact on the Cottonscope results was environmental conditions (temperature/relative humidity), and for fineness only. Good agreement was observed for maturity and fineness between the Cottonscope and the cross-section image analysis (IA) technique. The Cottonscope and IA methods were more responsive to changes in maturity and fineness than the AFIS method.

Introduction

Maturity and fineness are important cotton fiber properties, as they can impact the fiber's performance downstream. (USDA, 2001) Maturity is the degree of development or thickening of the fiber's secondary wall. (Wakelyn et. al., 2007) Fineness can be considered as the "size" of the fiber (linear density, diameter, cross-sectional area, perimeter), with linear density often used for processing and testing. (Wakelyn et. al., 2007) Maturity and fineness can be measured directly, but most of these methods are slow and laborious and/or require expensive laboratory equipment. Micronaire is a combination of the fiber's maturity and fineness, and, as a result, is often used to indirectly indicate the fiber's maturity and fineness. Recently, much interest has been expressed internationally on new techniques for maturity and fineness measurements that are user-friendly, rapid, precise, and accurate.

A new instrument was recently introduced for measuring simultaneously cotton fiber maturity, fineness, and ribbon width—the Cottonscope® (Figure 1; Cottonscope Pty Ltd, Perth, Australia). Image analysis and polarized light microscopy measurements are made on small longitudinal fiber snippets in a water bath. (Naylor et. al., 2011; Rodgers, 2011) In addition to average maturity (as maturity ratio or MR), fineness (mtex), and ribbon width, the Cottonscope also provides a distribution histogram for maturity and ribbon width. (Figure 2 for maturity) A program was implemented to determine the feasibility and capabilities of the Cottonscope to measure cotton fiber maturity and fineness and to determine key measurement impacts.

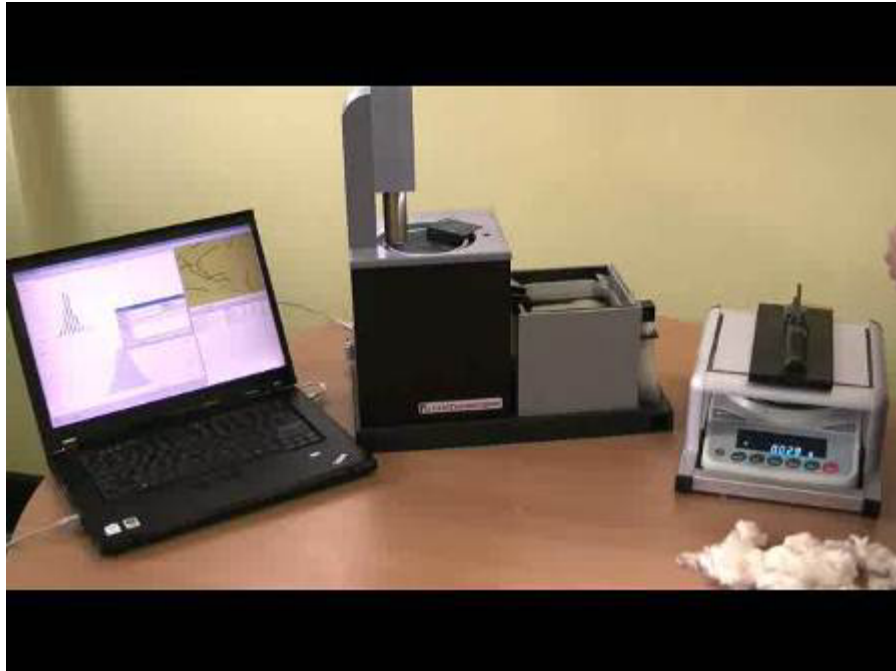


Figure 1. Cottonscope system (water tank/image analysis module, knife cutter, computer).

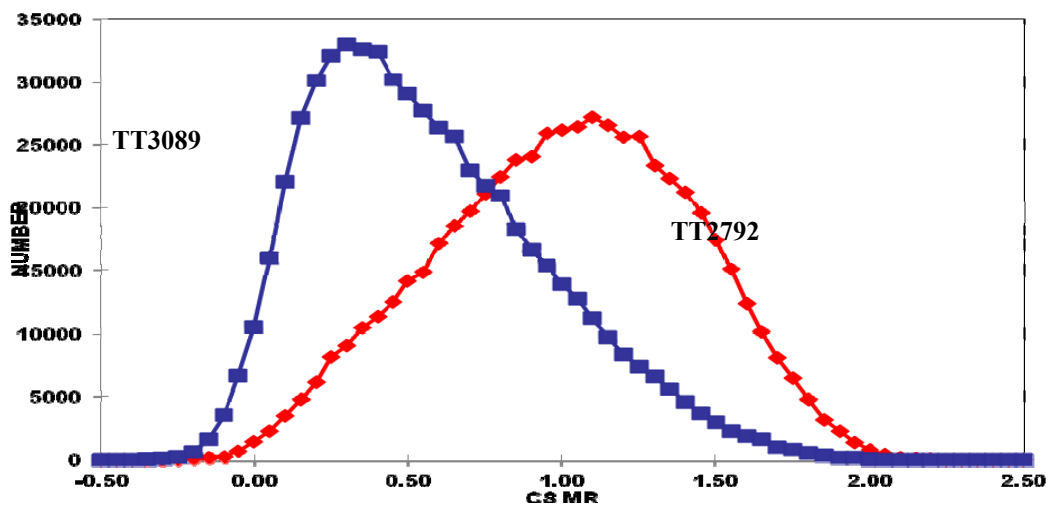


Figure 2. Example of the Cottonscope MR histogram, TT2792 (MR = 1.01) and TT3089 (MR = 0.57).

Material and Methods

The cotton lint used in this evaluation consisted of 104 well-defined, wide-range, diverse fiber samples. (Hequet et. al., 2006) The cross-sectional image analysis values for maturity and fineness served as the reference values for this evaluation. In addition to the cross-sectional image analysis method, the Cottonscope maturity and fineness results were compared to the corresponding Uster AFIS[®] Pro maturity and fineness results for the samples.

For the measurement impacts evaluations, a 6 sample subset of 104 sample set was used. Bleach addition impact was evaluated by performing Cottonscope measurements both with and without bleach addition (2 mL of sodium hypochlorite bleach added to 2 L of water in the water bath of the Cottonscope). The impact of environmental conditions (temperature, relative humidity or RH) was evaluated by placing the Cottonscope in two rooms with different environmental conditions—standard conditions 70°F/65% RH (70/65) and 74°F/45% RH (74/45). At both environmental conditions, Cottonscope measurements were made at the same condition at which the unit was calibrated and at the condition the instrument was not calibrated (environmental impact measurement). For example, calibrated at 70/65 and measured at 70/65 and 74/45; calibrated at 74/45 and measured at 74/45 and 70/65.

Parameters evaluated included R^2 and Standard Deviation of Differences residual analysis (SDD, the standard deviation of the differences between the reference and measured maturity/fineness value for each sample).

Results and Discussion

The Cottonscope measurement is very rapid and is easy to operate and maintain. Sample analysis time is 30-40 seconds, and sample preparation is ~45 seconds (cutting the sample and placing it into the water bath). For 3 loadings/cut samples and 2 reps per sample ($n=6$ total measurements), the total analysis time is 6-8 minutes (~8-10 samples per hour).

Measurement Impacts

Since the Cottonscope is a water-based system, algae growth with time was a concern. The vendor-recommended solution to this concern was the use of a small amount of bleach to the water bath in the Cottonscope. Evaluations on a small sample set demonstrated that the use of a small quantity of bleach to the water bath was not a major measurement impact (less than 0.01 maturity units and less than 2.0 millitex fineness differences between bleach and no bleach measurements).

The impact of environmental conditions on the Cottonscope maturity and fineness results was evaluated. Measurements were performed at both 70°F/65% RH (70/65) and 74°F/45% RH (74/45). The environmental condition impact on maturity was minimal (<0.01 from average), even with a 20% RH change. A distinct impact on fineness was observed (~7% per 20% RH change). However, the evaluation also demonstrated that the environmental condition impact on fineness can be significantly minimized by performing the Cottonscope measurements at the same environmental condition that the instrument was calibrated.

Maturity and Fineness Comparisons

The Cottonscope results for maturity and fineness were compared to the reference values for the cross-sectional image analysis (IA) method ($n=104$). Good agreement was observed for MR between the Cottonscope and IA results, with a moderate R^2 and low SDD (0.65 and 0.06, respectively). A distinct skew/bias was observed at high MRs (above 0.9), which accounted for most of the distinct Cottonscope outliers from linearity. Recent studies have shown that there is a bias in the original IA method software that leads to high MR values (Padmaraj et. al., 2011), and this bias leads to the moderate R^2 observed for MR. Good agreement was also observed for fineness between the Cottonscope and IA methods, with a R^2 of 0.79 and low SDD of 10.5.

In addition to the cross-sectional image analysis method, the Cottonscope maturity and fineness results were compared to the Uster AFIS®-Pro maturity and fineness results for 37 samples. (Figures 3 and 4) Good overall agreement was observed between the IA, Cottonscope, and AFIS maturity and fineness results. However, the AFIS results yielded slopes that were only ~50% of the slope observed between the IA and Cottonscope methods, indicating that the AFIS MR and fineness measurements are less responsive to changes in MR and fineness compared to the IA and Cottonscope methods.

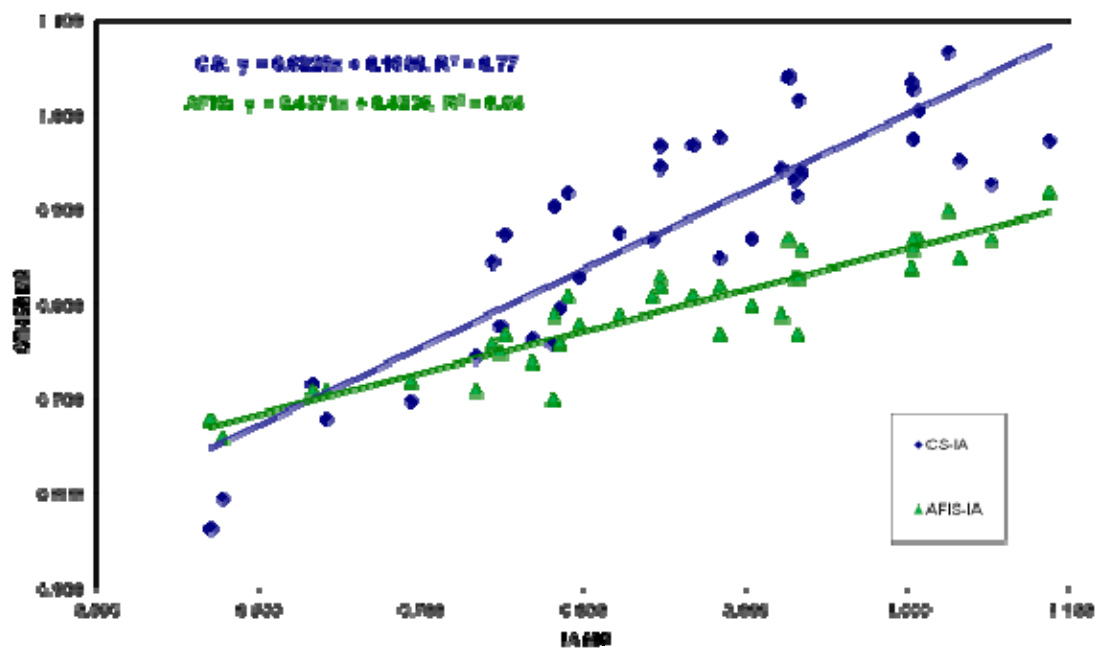


Figure 3. Comparison of the cross-sectional image analysis (IA), Cottonscope (CS), and AFIS measurements for MR (n=37).

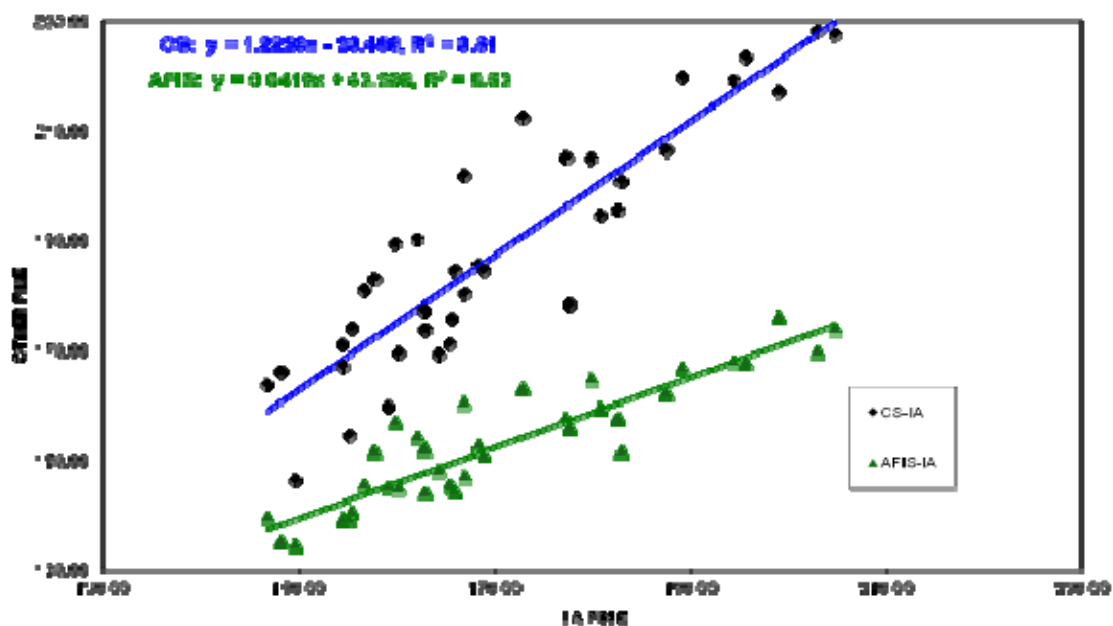


Figure 4. Comparison of the cross-sectional image analysis (IA), Cottonscope (CS), and AFIS measurements for fineness (n=37).

Summary

The recently introduced Cottonscope is a new, modular instrument for the simultaneous measurement of fiber maturity, fineness, and ribbon width. A program was implemented to determine the feasibility and capabilities of the Cottonscope to measure cotton fiber maturity and fineness and to determine key measurement impacts. The Cottonscope measurement of cotton fiber maturity and fineness was shown to be rapid, precise, accurate, and easy to perform. Six measurements on one sample can be performed in 6-8 minutes. The impact of a small amount of bleach addition to the water tank was not significant. The environmental conditions (temperature/relative humidity) under which the measurement was performed did impact the Cottonscope fineness measurements, but they did not impact the maturity results. Good agreement was observed between the Cottonscope and IA methods for maturity and fineness. Although good overall method agreement was observed between the Cottonscope, IA, and AFIS maturity and fineness results (based on R^2), the Cottonscope and IA methods were more responsive to changes in maturity and fineness than the AFIS method (higher slopes).

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Disclaimer

The use of a company or product name is solely for the purpose of providing specific information and does not imply approval or recommendation by the United States Department of Agriculture to the exclusion of others.

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