MULTIPLE FINENESS/MATURITY REFERENCE METHODS

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Abstract

The Shirley Developments Limited, SDL, Fineness and Maturity Tester, FMT, is calibrated using the British Standard Methods to measure maturity ratio and fineness. These parameters can also be calculated using fiber cross-section perimeter and circularity as measured by two image analysis systems to yield statistically similar data.

Introduction

Cotton fiber properties such as fineness and maturity ratio are used to calibrate the Shirley Developments Limited Fineness and Maturity Tester, FMT. Fineness and maturity ratio are typically measured using the time consuming and expensive British Standard Method, BSM (British Standard BS 3085:1981). Maturity ratio can also be calculated from fineness and micronaire using the Lord Equation (Lord, 1956). Image analysis of cotton fiber cross-sections measures fiber properties that can be used to calculate fineness and maturity ratio. For this research, two image analysis systems measured fiber properties of three cottons with a range of micronaires. These cottons were selected because they met or exceeded the International Calibration Cotton Standards, ICCS, specifications in tests for micronaire and uniformity as well as in preparation by blending and carding. The two imaging systems were found to measure fiber circularity and perimeter with no significant differences. From these properties, fineness and maturity ratio were calculated and compared to the BSM measured properties and no significant differences were found.

Materials and Methods

Fiber properties were measured on three cottons with high, medium and low micronaire values. These cottons were selected because they met or exceeded ICCS specifications in uniformity and micronaire as well as in preparation by blending and carding. Fiber fineness and maturity ratio were measured by British Standard Methods using 2000 to 3000 fibers (British Standard BS 3085:1981). Maturity ratios were also calculated from fineness and micronaire using the Lord Equation (Lord, 1956). Because of the time commitment and expense of BSM, image analysis was investigated as a means to calculate fiber fineness and maturity from measured properties. The image analysis circularity, calculated from non-swollen fibers was converted to maturity ratio using the constant 0.577, established by Peirce and Lord (Peirce and Lord, 1939). Fiber fineness is calculated using maturity ratio, calculated from fiber circularity, and fiber perimeter. Two different image analysis systems were compared for their ability to measure circularity and perimeter using a single factor ANOVA. The fineness and maturity ratio calculated from image analysis was compared to the BSM measured fineness and maturity ratio using a single factor ANOVA.

In order to perform image analysis on cotton fiber cross-sections, the Boylston cross sectioning method was used (Boylston et. al, 1991). Cotton fiber samples in amounts 0.1 g, were bundled and immersed in a methyl methacrylate, butyl methacrylate, and Luperco CDB catalyst mixture. In order to polymerize, the sample was placed in a UV chamber for 30 min. The sample was then blocked and cut with a diamond knife into 2 mm sections and affixed to a microscope slide coated with albumin.

Images of the cross sections were captured using a 20 x Nikon lens on a Nikon light microscope and the Leica imaging system. For each cotton, a series of images from the cross section is generated and typically contains 300 to 500 fibers. These images were analyzed using two image analysis systems. One was the Leica Quanitmet 600 Image Analysis system with the Quips language to measure fiber properties such as perimeter and circularity (Thibodeaux and Evans, 1986). The Fiber Image Analysis system, FIA, was developed by Dr. Bugao Xu at Texas Tech and measures fiber properties on the same images that were analyzed by Leica (Xu-B; and Ting-Y-L, 1996).

Results and Discussion

Three cottons with a range of micronaires were blended and carded to exceed ICCS preparation specifications (Table 1). These cottons, designated low, medium, and high micronaire, were subjected to the British Standard Methods to measure fiber fineness and maturity ratio (British Standard BS 3085:1981). Approximately 2000 to 3000 fibers were analyzed to arrive at these BSM values (Table 2). The Lord Equation was also used to calculate maturity ratio from fineness and micronaire, and was compared to the measured values of BSM comparing very similarly as demonstrated in Figure 1 (Lord, 1956).

Measuring fiber properties by BSM is time consuming and costly, thus, image analysis was studied as an alternative (Thibodeaux and Evans, 1986). The two cotton fiber properties critical to calculating fineness and maturity ratio are perimeter (mm) and circularity (theta). These fiber properties can be measured using image analysis, thus two different systems, Leica and FIA, were compared. Both

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systems measured cotton fiber properties on the same images containing a total of 300 to 500 fibers and produced results that were not statistically different as seen with a single factor ANOVA. This is demonstrated in Figure 2 and Table 3, indicating there are no significant differences of the perimeters as measured by the two imaging systems. Figure and Table 3 indicate that circularity is not significantly different for the two imaging systems.

Because the two different image analysis systems were measuring perimeter and circularity with no statistical differences, these parameters were used to calculate fineness and maturity ratio. Maturity ratio is calculated from circularity as measured by image analysis on non-swollen fibers. In order to compare with the swollen fibers measured by BSM, the Peirce and Lord constant, 0.577 was used to calculate maturity ratio (Pierce and Lord, 1939). Using the image analysis converted maturity ratio and micronaire, fiber fineness can be calculated. Because the FIA system requires fewer operator involvements, the calculated fineness and maturity ratio were compared the measured BSM values. There were no statistically significant differences between those values measure by BSM and those calculated by image analysis, Figures 4 and 5 and in Table 3.

Conclusions

The British Standard Method for measuring fiber fineness and maturity ratio is both costly and time consuming. Image analysis using the Boylston Technique to polymerize and section cotton fibers provides a faster and cheaper alternative. Cotton fiber circularity and perimeter as measured by two different image analysis systems were not statistically different from each other. These cotton fiber properties can be used to calculate fineness and maturity ratio using the image analysis data, which were not significantly different from the measured BSM properties.

References

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Table 1. Micronaire Values as established by the ICCS Method

Cotton	Micronaire
High	5.37
Medium	4.34
Low	3.58

Table 2. British Standard Methods Measured Fineness & Maturity Ratio

Cotton	Fineness (mtex)	Maturity Ratio
High	220.0	1.0033
Medium	195.3	0.8902
Low	169.7	0.7483

Table 3. Statistical Results Comparing Image Analysis Systems

Fiber Property	p-Value High Mic	p-Value Med Mic	p-Value Low Mic
Perimeter: ^{P}Lica, ^{P}FIA	0.52	0.067	0.085
Circularity: ^{Theta}Leica ^{Theta}FIA	0.27	0.51	0.086
Fineness: ^{H}BSM, ^{H}FIA	0.944	0.926	0.915
Maturity Ratio: ^{MR}BSM ^{MR}FIA	0.654	0.902	0.714

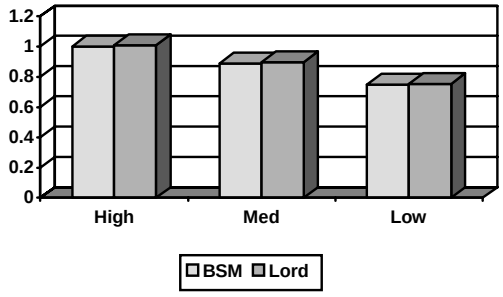

Figure 1. Maturity Ratio as Measured by BSM and Calculated by the Lord Equation

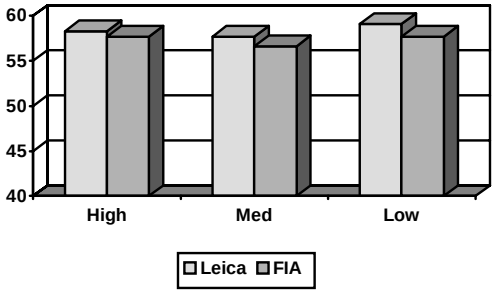

Figure 2. Perimeter as Measured by Leica and FIA Imaging Systems

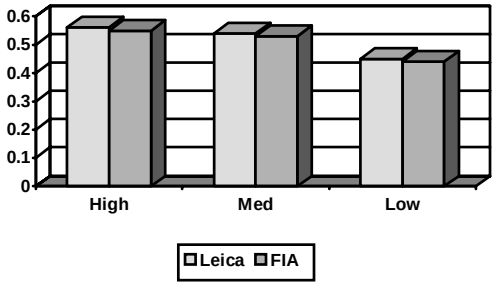

Figure 3. Circularity as Measured by Leica and FIA Imaging Systems

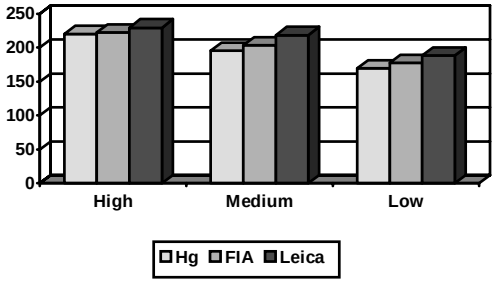

Figure 4. Fiber Fineness as Measured by BSM and Calculated by Image Analysis

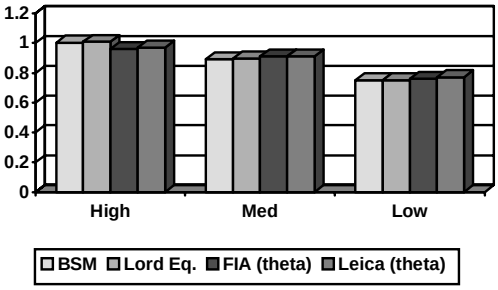

Figure 5. Maturity Ratio as Measured by BSM and Calculated by the Lord Eq. and Image Analysis