CALIBRATION OF UPGRADED FMTS

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Abstract

Four FMTs (Fineness and Maturity Tester) were upgraded at SRRC and calibrated. The calibration compares data gathered from a dozen cottons, averaged across several independent reference methods, to the FMT data. Two of the reference methods are the British Standard Methods (BSM) — used in the original calibration — and image analysis. The FMTs were calibrated at the standard airflows of 4 and 1 L/min with the sample cell volume varied to produce the desired pressure drops through the cotton. A variety of relationships exist between the FMT and reference data sets, from polynomial to linear with designated slopes and intercepts to a constant offset. This paper will demonstrate the relationships and show that the constant offset is the easiest and most direct route to accurate FMT calibration.

Introduction

There are two measured values of the FMT, which can be converted to maturity and fineness. These measurements are PL, for the low compression with 4 L/min of air drawn through, and PH, high compression with 1 L/min of air drawn through. Fineness and maturity ratio were measured using British Standard Method, BSM (British Standard BS 3085:1981, BS EN ISO 1973:1996). Maturity ratio was also 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, twelve cottons were selected because of their wide range of micronaires. The maturity and fineness of the twelve cottons were converted to PL and PH to calibrate the FMT.

Materials and Methods

Fiber properties were measured by independent reference methods on twelve cottons with a range of micronaire values. Generally, fiber fineness and maturity ratio were measured by British Standard Methods using 2000 fibers (British Standard BS 3085:1981 and BS EN ISO 1973:1996). Maturity was also measured by the Lord Micronaire equation, given micronaire by the Micromat instrument and fineness by British Standard Method.

The Boylston cross sectioning method was used to generate the cotton fiber cross sections used for image analysis (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 µm 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 the Fiber Image Analysis system, FIA, developed by Dr. Bugao Xu (Xu-B; and Ting-Y-L, 1996). 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.

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Near infrared reflectance spectroscopy (NIR) was used to check if the reference method data for the 12 cottons by the other methods, produced from a very small number of fibers, was representative of a bulk sample (40 grams, the sample size for NIR) of the calibration cottons. Near Infrared Spectral Analysis Software, NSAS, by NIRSystems, Inc. was used to generate the spectra and data. The NIR was calibrated with other data for micronaire, fineness and maturity. The small differences between the NIR predicted values and the measured values was used as a correction factor to smooth the data.

The micronaire, fineness, and maturity values by the various reference methods, were averaged across the methods to produce declared values for micronaire, fineness and maturity. These declared values were used as input data in a computer program to back calculate Lord's FMT model to produce declared PL and PH values for the twelve cottons.

The differences between the declared PL and PH values, generated from BSM, NIR and image analysis, and those observed by FMT were compared. The goal was to identify the easiest and most reliable relationship possible to ensure the proper calibration of the FMT.

The samples were prepared for FMT testing using four-gram fiber samples that were carded using Louete cotton hand cards with 100 picks per inch. The carded sample was then rolled into a sliver with a diameter approximately 2 inches. The sliver was inserted into the FMT chamber using a trough and a pronged mechanical device. Operators handled the cotton only to weigh the sample and place it on the cards, after that the operator did not touch the cotton sample.

Results and Discussion

The declared micronaire and fiber properties for the twelve cottons were compared to those measured by FMT. The declared values of PL and PH were generated from the mean of BSM, NIR and image analysis techniques. Maturity and fineness were measured directly using BSM; calculated using parameters measured by image analysis and predicted using NIR.

By altering the volume of the chamber in small increments, the relationship between target values subtracted from observed values as compared with micronaire varies greatly. Figure 1 demonstrates a polynomial relationship between target values subtracted from observed values that diverges at higher micronaire values. One of the major problems with the relationship described by Figure 1 is the discrepancy between PL and PH, which would result in different correction factors for the two compressions. The other major problem is that the differences vary greatly with miconaire. Figure 2 shows a crossing polynomial relationship. Similar problems arise with the crossing relationship as with the divergent one. In the constant offset relationship, Figure 3, the differences between observed and target values for PL and PH are nearly indistinguishable, and are constant across micronaires. This offers a simple and easy calibration of the FMT, simply subtract the difference from both PL and PH and then calculate maturity and fineness.

Utilizing the constant offset relationship, the mean difference between observed and target values are subtracted for PL and PH and then maturity and fineness are calculated. Relating these adjusted PL and PH calculated maturity and fineness values to those of the mean of the BSM, NIR and image analysis good correlations were discovered. Figure 4 indicates the strong relationship between the adjusted and declared micronaire while Figure 5 shows the relationship for maturity, Figure 6 for fineness. As can be seen from these graphs, the correlation is quite good indicating that using the constant offset technique can correlate the FMT to the declared data.

The sample preparation for the FMT included hand carding with a card containing cotton clothing, rolling into a sliver, and placing the sample in the chamber by mechanical means. This eliminated any operator effects.

Conclusions

The constant offset between the declared and observed values seems to be the easiest and most direct way to calibrate the FMT. With a mere subtraction of the offset, there is high correlation between the declared and observed PL, PH, micronaire, maturity and fineness data.

Acknowledgments

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References

Boylston, E. K.; Hinojosa, O.; Hebert, J. J. A Quick Embedding Method for Light and Electron Microscopy of Textile Fibers. Biotechnic Histochem, 1991, p. 122-124.

British Standard BS 3085:1981. Method for evaluation of the maturity of cotton fibres (Microscopic Method). British Standards Institution, London.

British Standard BS EN ISO 1973:1996. Textile fibres-Determination of linear density-Gravimetric methods and vibroscope. British Standards Institution, London.

Lord, E. Airflow through plugs of textile fibres. Part II. The micronaire test for cotton. J. Textile Institute, 47, T16-47(1956).

Manual of Near Infrared Spectral Analysis Software, NIRSystems, Inc. 1990.

Peirce, F. T., and E. Lord. The Fineness and Maturity of Cotton. Journal of the Textile Institute. December, 1939. p. T173-210.

Thibodeaux-DP; Evans-JP. Cotton fibre maturity by image analysis. Textile-Research-Journal. 1986; 56: No.2, 130-139.

Xu-B; Ting-Y-L. Fiber-image analysis. I. Fiber-image enhancement. Journal-of-the-Textile-Institute. 87/2-1996 p. 274-283.

Xu-B; Ting-Y-L. Fiber-image analysis. II. Measurement of general geometric properties of fibers. Journal-of-the-Textile-Institute. 87/2-1996, p. 284-295.

Lord, E. Airflow through plugs of textile fibres. Part II. The micronaire test for cotton. J. Textile Institute, 47, T16-47(1956).

Peirce, F. T., and E. Lord. The Fineness and Maturity of Cotton. Journal of the Textile Institute. December, 1939. p. T173-210.

Thibodeaux-DP; Evans-JP. Cotton fibre maturity by image analysis. Textile-Research-Journal. 1986; 56: No.2, 130-139.

Xu-B; Ting-Y-L. Fiber-image analysis. I. Fiber-image enhancement. Journal-of-the-Textile-Institute. 87/2-1996 p. 274-283.

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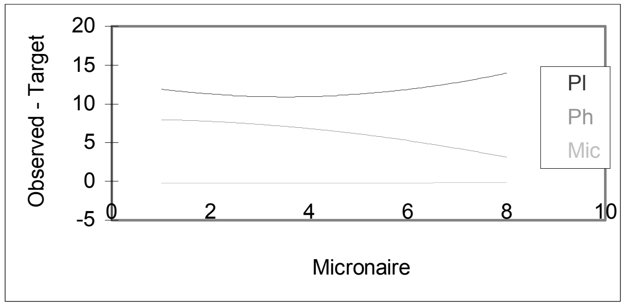

Figure 1. Divergent polynomial relationship between observed and target values.

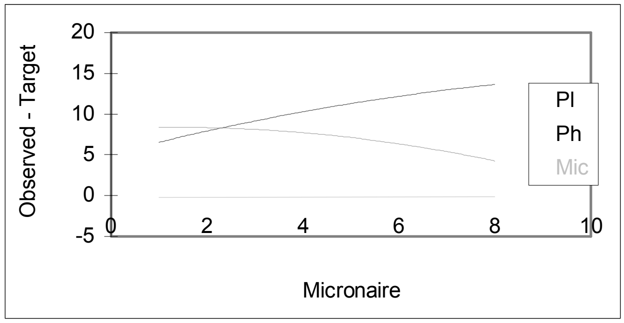

Figure 2. Crossing polynomial relationship between observed and target values.

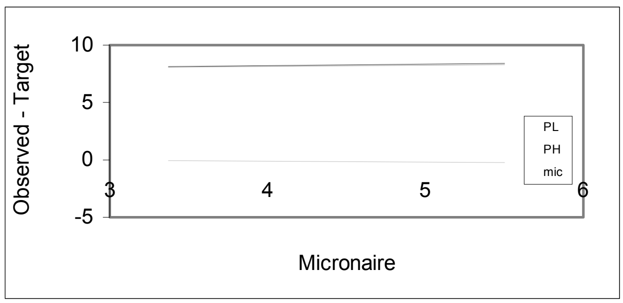

Figure 3. Constant linear offset relationship between observed and target values.

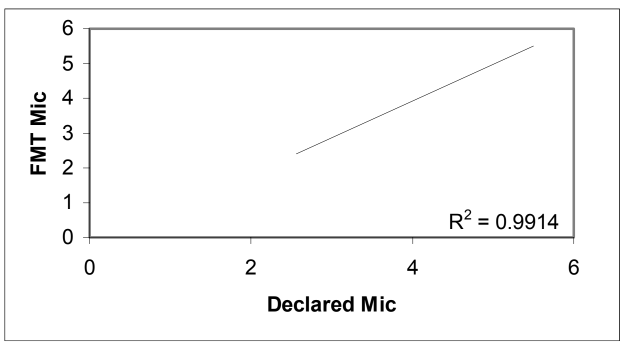

Figure 4. Relationship between adjusted observed and declared micronaire.

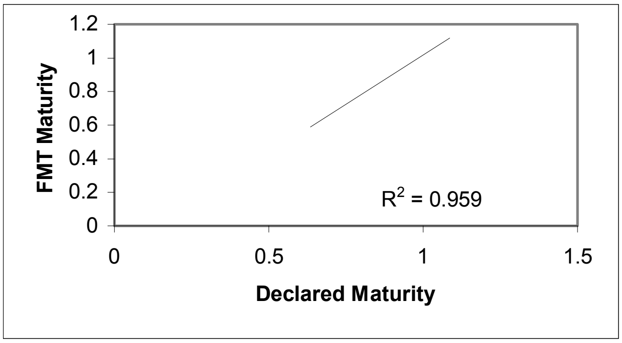

Figure 5. Relationship between adjusted observed and declared maturity.

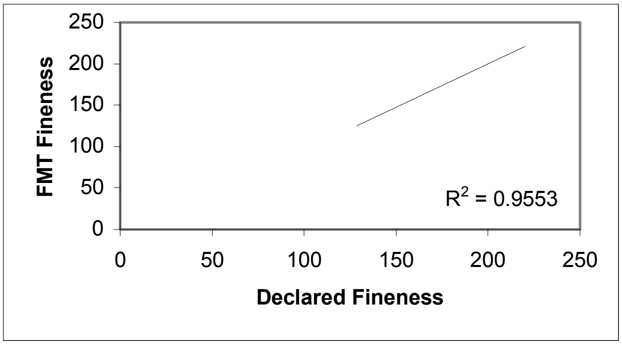

Figure 6. Relationship between adjusted observed and declared fineness.