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TEXTILE TECHNOLOGY

Relationships Between Micronaire, Fineness, and Maturity. Part I. Fundamentals

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ABSTRACT

Micronaire has been used as a substitute for assessing cotton (*Gossypium hirsutum* L.) fineness and maturity when these measures are not available. Variability in R^2 between the paired fiber properties (micronaire and maturity, micronaire and fineness, and maturity and fineness) has been observed. There is a need to model the relationships between these variables to understand the changes in R^2. The objective of this study was to develop and compare models between micronaire, fineness, and maturity in terms of the cross-sectional dimensions of wall thickness and perimeter. The models were computer simulated over the full range of thickness and perimeter values, the simulated data plotted, and the relative sensitivity to changes in thickness and perimeter calculated. Families of lines were produced by plots of wall thickness at constant perimeter versus micronaire, fineness, and maturity, and by plots of micronaire versus fineness and maturity. The paper evaluates R^2 values that would be obtained if the various relationships were fitted using a simple linear model. Additionally, the micronaire model is significantly more sensitive to a change in wall thickness (in µm) compared with the same change in perimeter, especially at small thickness values where micronaire is almost independent of perimeter. As thickness increases, i.e., for high micronaire cottons, the sensitivity to perimeter becomes larger. These simulations show how wall thickness and perimeter together affect fineness, maturity and ultimately micronaire.

Micronaire is one of the two most important fiber characteristics for international cotton classers and spinners (Heap, 2000). Micronaire is an indicator of air permeability. It is regarded as an indication of both fineness (linear density) and maturity (degree of cell-wall development). For a given type of cotton, a relatively low micronaire has been used as a predictor of problems in processing, but a low micronaire may also indicate fine fibers with adequate maturity. Similarly, growers may be discounted for high micronaire when, in fact, the fibers have adequate fineness and good maturity, because high micronaire fibers are normally coarse, which is undesirable from the point of view of spinning and yarn evenness. Fineness is generally expressed as gravimetric fineness or linear density (wall area times a constant) (Ramey, 1982), and maturity is generally expressed as maturity ratio (wall area divided by perimeter squared) (Lord and Heap, 1988). One of the first practical tools to measure fineness and maturity was the determination of linear density and maturity ratio on the Shirley Developments Limited Fineness and Maturity Tester (FMT), which has been improved (Montalvo and Faught, 1999; Von Hoven et al., 2001). It is the standard in this laboratory to calibrate high-volume near infrared instrumentation (NIR HVI) for micronaire, fineness, and maturity (Buco et al., 1998).

Although linear density, maturity ratio, and micronaire are useful to spinners, all three properties can be viewed for any given cotton in terms of wall thickness and perimeter. Wall area is a function of wall thickness and perimeter (Montalvo, 1991a; 1991b; Montalvo et al., 1991). Wall thickness and perimeter are fundamental cross-sectional characteristics of the fiber with respect to wall area, because the function cannot be decomposed further into other geometric measures. If one examines the fiber cross-section, the wall thickness is not constant but varies around the fiber, so that points must be sampled to get an averaged value. As a consequence, an averaged wall thickness and perimeter are fundamental with respect to an averaged wall area. Exploring the relationships on a fundamental level can be beneficial by demonstrating how a unique wall thickness and perimeter value together give an equivalent micronaire-fineness-maturity combination.

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Cottons with a much greater genetic diversity are being developed, and a greater range of both fiber perimeter and wall thickness, and their combinations, is probable. Consequently, the relationships between micronaire, fineness, and maturity are being modified (Heap, 2000). This is because the original set of U.S. cottons that were used to calibrate the micronaire instrument had perimeters with a smaller range compared to current cultivars. The original relationships apply best to those cottons having perimeters similar to the calibration samples. For other cottons, these relationships do not apply as well, which results in modified expressions.

Even though micronaire is of great practical value for trade and industry, a literature review indicated no theoretical or experimental studies have been reported that model the three fiber characteristics in terms of the fundamental measures of thickness and perimeter. The specific objectives of this research were to use fineness and maturity components – wall thickness and perimeter – to develop models for fineness, maturity, and micronaire; to simulate the interaction of fineness and maturity and the resultant micronaire; to quantify the relative sensitivity of the models to changes in thickness and perimeter; and to demonstrate variability in the coefficients of determination between micronaire and the other variables. Part II of this series will be devoted to fitting the models and diagnostic criteria (i.e., plots to confirm the fit of a specific model) to experimental data.

THEORY

Physical Meaning and Models

Wall area. The equation for cotton fiber wall area A_w (µm^2) as a function of wall thickness T (µm) and cross-sectional perimeter P (µm) is given by (Montalvo, 1991a):

$$A_w = T(P - \pi T) \qquad \text{[Eq. 1]}$$

and after rearranging terms to solve for T:

$$T = \frac{P - \sqrt{P^2 - 4\pi A_w}}{2\pi}. \qquad \text{[Eq. 2]}$$

It should be noted that the derivations of Eqs. 1 and 2 are rigorous. The first equation was derived by two independent approaches. When the first equation is substituted into the second, the square root terms form a perfect square and reduces to $T = T$. This proves the correct root of Eq. 2 by the quadratic formula for wall thickness.

Fineness and maturity. Fiber fineness and maturity can be expressed in various ways (Ramey, 1982; Lord and Heap, 1988; and Montalvo and Faught, 1996). In this paper, fineness (H) is gravimetric fineness or linear density of fibers expressed in millitex (mtex, micrograms per meter). The density of the cell wall is taken as 1.52 g/cm^3 (Ramey, 1982). The resulting equation is:

$$\begin{aligned} H &= 1.52A_w = 1.52T(P - \pi T) \\ &= 1.52TP - 1.52\pi T^2. \end{aligned} \qquad \text{[Eq. 3]}$$

Maturity (M) in this context is the maturity ratio; it is the degree of thickening divided by 0.577 and is dimensionless. Degree of thickening (θ) is wall area divided by the area of a circle having the same perimeter (Lord and Heap, 1988):

$$\theta = \frac{4\pi A_w}{P^2} \qquad \text{[Eq. 4]}$$

and the expression for M is:

$$M = \frac{\theta}{0.577} = \frac{4\pi A_w}{0.577P^2} = \frac{4\pi T(P - \pi T)}{0.577P^2}. \qquad \text{[Eq. 5]}$$

Micronaire. The micronaire reading represents an arbitrary scale of relative values and does not directly evaluate any single physical fiber property (Heap, 2000). Micronaire represents a combined measure of cotton fineness and maturity. There is a direct relationship between micronaire and the product MH.

This relationship was first substantiated for a set of 100 cottons analyzed for fineness and maturity (Lord, 1956) where Mic is micronaire:

$$MH = 3.86Mic^2 + 18.16Mic + 13 \qquad \text{[Eq. 6]}$$

with an R^2 of 0.9809. The relationship has been confirmed by several workers with very similar results: R^2 = 0.998 (Lord and Heap, 1988); R^2 = 0.988 (Mitchell, 1976); and Bremen round tests, R^2 = 0.990 and image analysis, R^2 = 0.917 (Heap, 2000).

Solving Eq. 6 for micronaire and substituting Eqs. 3 and 5 into the new expression:

$$\begin{aligned} Mic &= 0.509\sqrt{(MH + 8.359)} - 2.352 \\ &= 2.929\sqrt{\frac{(A_w)^2}{P^2} + 0.2525} - 2.352 \end{aligned} \qquad \text{[Eq. 7]}$$

and:

$$Mic = 2.929\sqrt{(\frac{T^2(P - \pi T)^2}{P^2} + 0.2525)} - 2.352. \qquad \text{[Eq. 8]}$$

Other micronaire models. Thibodeaux (1998) and Thibodeaux et al. (2000) published a micronaire equation where A is wall area:

$$Mic = \sqrt{(\frac{8.56A^2}{P^2} + 1.196)} - 2.35. \qquad \text{[Eq. 9]}$$

A small discrepancy in micronaire values (<2.5%) was found when Eqs. 7 and 9 were compared at a wall area of 100 µm^2 and a perimeter of 50 µm. This difference could be due to rounding errors. (The derivation or proof of Eq. 9 has not been reported.)

Worley et al. (1975) derived the following equation relating micronaire to the Arealometer specific surface area (SSA):

$$SSA = 1904.8 + 169.32\,Mic - 1047.4\sqrt{Mic}. \qquad \text{[Eq.10]}$$

Montalvo and Vinyard (1993) solved Eq. 10 for micronaire, derived an expression as a function of A_w and P and reported two new expressions:

$$Mic = 17.1 - 42.3\frac{P}{A_w} + 32\frac{P^2}{(A_w)^2} \qquad \text{[Eq. 11]}$$

and:

$$Mic = 17.1 - 42.3\frac{P}{T(P - \pi T)} + 32\frac{P^2}{T^2(P - \pi T)^2}. \qquad \text{[Eq. 12]}$$

APPROACH

Data Ranges, Simulation and Statistical Methods

The observed ranges (worldwide, Egyptian to short staple coarse) of fineness, maturity and micronaire are 118 to 256 millitex, 0.5 to 1.1, and 2 to 6 micronaire units, respectively (Ramey, 1982; Lord, 1988). The practical ranges of wall thickness and perimeter to use in the simulation were calculated from the observed ranges of fineness and maturity ratio. These values are 1.4 to 3.4 µm and 35 to 60 µm, respectively. The equivalent range of wall area is 78 to 168 µm^2.

The strategy in the data simulation was to use Microsoft Excel 2000 (Redmond, WA) to generate fineness, maturity ratio, and micronaire values as thickness varied at 0.1 µm intervals over the range 1.4 to 3.4 µm at six values of perimeter: 35, 40, 45, 50, 55 and 60 µm. This produced 21 x 6 = 126 data points for each family of lines in the study unless stated otherwise.

In simulations, the hypothetical or theoretical data is usually presented in figures as smooth lines without showing the points. That format is followed in this paper; however, the data points were used to compute R^2 values by Excel's data analysis software.

RESULTS AND DISCUSSION

Functional Relationships

Wall area, fineness, and maturity. The functional dependence of wall area (Eq. 1) on wall thickness at constant perimeter (Montalvo, 1991a) revealed a family of lines that peaked at maximum wall thickness. At the peak, the width of the fiber wall is, in fact, the radius of the solid fiber. (To prove the existence of a maximum value rather than a plateau in the wall area relationship, it was necessary to plot beyond the point of inflection. That same plotting format is used in this paper. It should be emphasized, however, that only those thickness values leading up to the peak are real.)

Gravimetric fineness (H) (Eq. 3) is a function of wall area A_w and cellulose density. It is assumed that the density is constant. (Work is in progress at SRRC and elsewhere to test this hypothesis.) The dependence of H on thickness (T) at constant perimeter (P) (Fig. 1) gives a family of lines that converges as T approaches zero. As expected, the peak shifts to the right with increase in P. Note that the normal range of T and P values is bracketed by the vertical dashed lines in the figure.

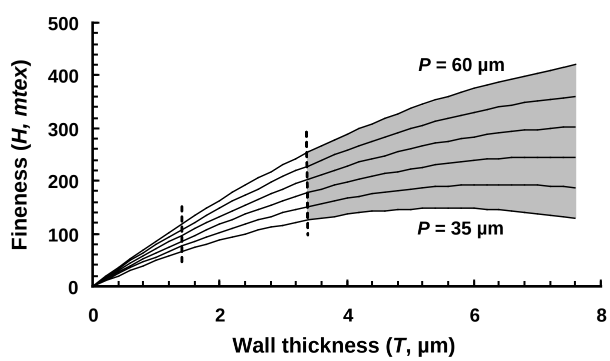

Figure 1. Functional dependence of fineness on wall thickness at six perimeter values (35, 40, 45, 50, 55 and 60 µm). The shadowed area outside the normal range is included in the family of lines to prove the existence of a maximum value rather than a plateau and to show its dependence on perimeter. This illustrates the unique features of wall area plots. Only those thickness values leading up to the peak are real.

Mathematically the term *TP* in Eq. 3 causes separation of the lines with each increase in *P*. With an increase in *T* at a constant *P*, the term T^2 changes at a rate greater than that for *TP* so each line eventually depicts a maximum value. (Again, the region of the lines does not exist physically beyond the maximum value. This region is included in Figures 1 and 2 to document a peak exists and to show its dependence on perimeter. Thus, Figures 1 and 2 provide the necessary graphical proof that the characteristics of the plots are due to the wall area term in the expressions.)

Maturity ratio *M* (Eq. 5) is a function of the ratio of A_w to P^2. The resultant family of lines (Fig. 2) shows the expected A_w curves that peak at maximum wall thickness concomitant with the radius of the solid fiber. Mathematically, the reversal of the order of the family of curves in Figures 1 and 2 is because the term in P appears in the numerator in one equation and the denominator in the other.

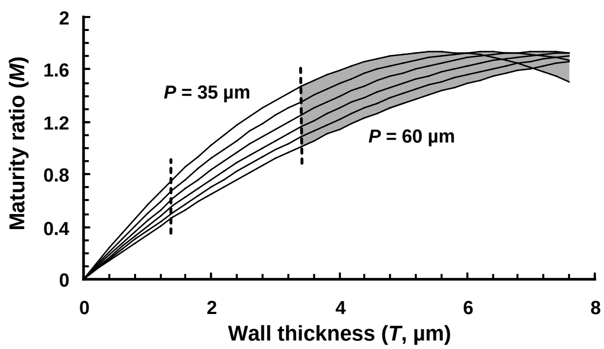

Figure 2. Functional dependence of maturity ratio on wall thickness at six perimeter values (35, 40, 45, 50, 55 and 60 µm). The shadowed area outside the normal range is included in the family of lines to prove the existence of a maximum value rather than a plateau and to show its dependence on perimeter. This illustrates the unique features of wall area plots. Only those thickness values leading up to the peak are real.

When fineness is plotted against maturity ratio at constant perimeter (Fig. 3), a family of lines is obtained that converges at the origin. Since both fineness and maturity are functions of wall area, the relationship can be reduced to $H = KMP^2$, where the constant K = 0.069792. This is the equation for a straight line – at constant *P* – that passes through the origin, so a necessary condition for *H* to be related to *M* in comparing two or more cottons, is that *P* is constant. Under this constraint, given *H* or *M*, the other fiber property may be easily calculated. Distribution of fineness and maturity for a smaller range of perimeters (43 - 58 µm) also produced a family of straight lines (Thibodeaux, 1998).

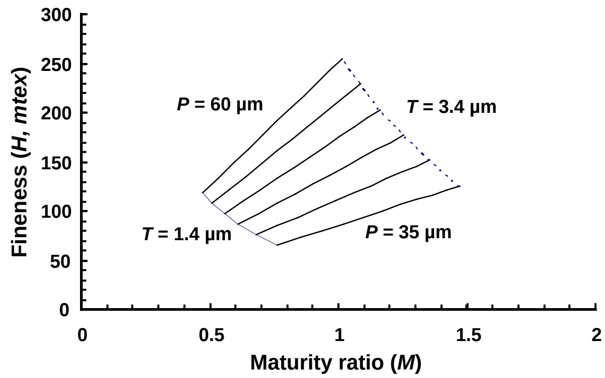

Figure 3. Relationship between fineness and maturity ratio at six perimeter values (35, 40, 45, 50, 55 and 60 µm).

Micronaire, fineness, and maturity. The maturity-fineness-micronaire model described by Eq. 6 has been confirmed by several workers: R^2 = 0.988 (Mitchell, 1976); R^2 = 0.998 (Lord and Heap, 1988); and Bremen round tests, R^2 = 0.990 and image analysis, R^2 = 0.917 (Heap, 2000). This model is used herein to shed light on what happens when the independent variables are changed (from *H* and *M,* then to A_w and *P,* and finally to *T* and *P*). To understand functional relationships of complex systems like this, it is useful to look at the different families of lines.

The right side of Eq. 6 is a quadratic function. At fixed micronaire, *M* is inversely proportional to *H* and vice versa. Figure 4 demonstrates this relationship at five values of micronaire and is in agreement with published curves at micronaire 3, 4 and 5 (Thibodeaux, 1998). Although descriptive of Eq. 6, the curves do not reveal the changes in the fundamental measures of wall thickness and perimeter. Thus, to appreciate these changes, a series of three micronaire figures is presented at constant *P*.

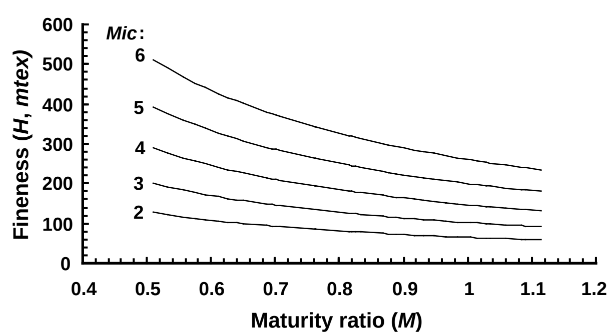

Figure 4. Demonstration of inverse relationship between fineness and maturity ratio at constant micronaire.

Figure 5 is the first in the series and depicts a plot of micronaire calculated by Eq. 8 at six *P* values. At the lower limit of *T* values in the model (1.4 µm), the curves tend to converge indicating a reduced dependence of micronaire on perimeter. At the allowed upper limit of *T* (3.4 µm), micronaire ranges from 4.72 to 5.96, a difference of 1.24. The more recent expression of micronaire (Eq. 12) shows a similar dependence of micronaire on *T* at constant *P*. At a *T* value of 3.4 µm, the difference in micronaire is 1.3 units. At a T value of 3.4 µm and P value of 50 µm, Eqs. 11 and 12 give essentially the same numerical values as Eqs. 7, 8, and 9. The difference is <0.15.

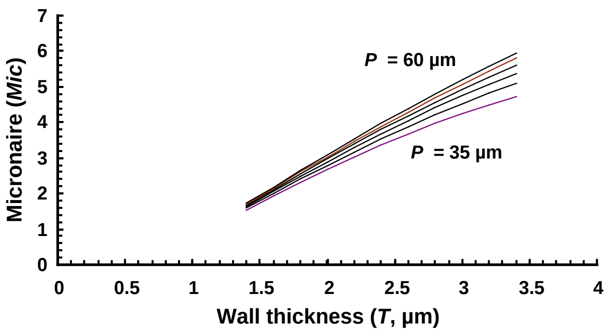

Figure 5. Dependence of micronaire on wall thickness at six perimeter values (35, 40, 45, 50, 55 and 60 µm).

The family of lines in Figure 5 is similar to that in Figures 1 and 2, suggesting that Eq. 8 is another plot of the form of wall area versus *T* at constant *P*. Simulation calculations confirm that for $P = 35$ µm the curve peaks when the wall thickness is, in fact, equal to the radius of the solid fiber (5.57 µm). (As *T* approaches zero, the simulation gives negative micronaire values – imaginary). This is because the first term in Eq. 8 approaches zero and the intercept term is negative. It is also outside the region of validity of Eq. 6.)

The modeling results in Figure 5 suggest that the peaking effect on the curves at low perimeter values is a controlling factor that does not allow for high micronaire cotton. Unfortunately, given higher perimeters at the upper practical limit of *T* (3.4 µm), this phenomenon no longer determines the outcome, and the modeling results allow for high micronaire fibers. Note also that at constant *T,* as *P* decreases at a fixed increment of 5 µm, the simulation predicts an increase in the rate at which micronaire goes down.

Additionally, the micronaire formulas can be simplified to show that micronaire is a function of A_w/P. This is easy to see in the right side of Eq. 7 if one ignores all numerical constants, and takes the square root of the independent variables. Similarly, micronaire is a function of A_w/P in Eq. 9 and P/A_w in Eq. 11. Why in one case is the ratio A_w/P and in the other it is P/A_w? As pointed out by Lord and Heap (1988), a consequence of the joint varying effect of *H* and *M* is that it is necessary to use complicated equations in the models. This results in alternative expressions for any given series of cottons, which satisfy the experimental data.

The two remaining plots in the series, Figures 6 and 7, depict micronaire (Eq. 8) versus fineness and maturity, respectively, at constant perimeter. In both figures, a family of straight lines is produced within the wall thickness range of 1.4 to 3.4 µm. This is due to the fact that all three fiber characteristics – micronaire, fineness, and maturity – are functions of wall area. Observe that at constant *P*, *Mic* is a function of *H*, and *Mic* is a function of *M*.

Table 1 summarizes the models and expected characteristics of the plots. Families of lines were observed in all plots. Column 5 lists the variables in each plot that are functions of wall area.

Table 1. Characteristics of models and predicted features of corresponding plots [z]

Figure	[Eq.]	*y*-axis	*x*-axis	Family of lines		
				F(wall area)	Curved	Straight
1	3	*H*	*T*	*H*	✓	
2	5	*M*	*T*	*M*	✓	
3	3 & 5	*H*	*M*	*H & M*		✓
4	6	*H*	*M*	*H & M*	✓	
5	8	*Mic*	*T*	*Mic*	✓	
6	3 & 8	*Mic*	*H*	*Mic & H*		✓
7	5 & 8	*Mic*	*M*	*Mic & M*		✓

[z] ***T*** **= wall thickness,** ***H*** **= fineness,** ***M*** **= maturity ratio, and** ***Mic*** **= micronaire.**

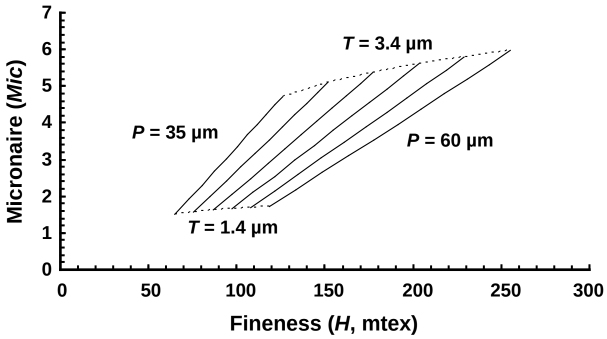

Figure 6. Relationship between micronaire and fineness at six perimeter values (35, 40, 45, 50, 55 and 60 μm).

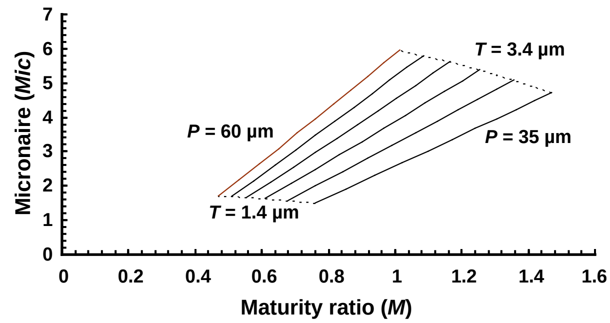

Figure 7. Relationship between micronaire and maturity ratio at six perimeter values (35, 40, 45, 50, 55 and 60 μm).

Relative Sensitivity to Changes in Wall Thickness and Perimeter

Do the curves at constant perimeter fall close together (Figures 1, 2, and 5) because the functions are more sensitive to a change in T (in μm) compared to the same change in P? Due consideration is given in this section of the paper to answering this question. It matters because sensitivity to a change in T and P affects, for example, the R^2 between the variables, as demonstrated in the next section.

The relative sensitivity of the functions to T and P is listed in Table 2 at the normal limits of the independent variables. For all four functions (wall area, fineness, maturity and micronaire), the relative sensitivity is quantified by taking the ratio of the change in the function (F) with respect to T at constant P divided by the change in F with respect to P at a constant T. In mathematical terms, this is the ratio of partial derivatives, $(\partial F/\partial T)_P / (\partial F/\partial P)_T$.

An example calculation of the partial derivative ratios for wall area A_w at the default values of P = 35 μm and T = 1.4 μm follows. The first step in the process was to derive the expression:

$$\frac{\left(\frac{\partial A_w}{\partial T}\right)_P}{\left(\frac{\partial A_w}{\partial P}\right)_T} = \frac{(P - 2\pi T)}{T}. \qquad \text{[Eq. 13]}$$

Then, using the default P and T values, the computed ratio of partial derivatives is 18.7. The larger the ratio, the greater the relative sensitivity to a change in T compared to a change in P.

Examination of Table 2 reveals that the sensitivity of the functions to a change in T compared to a

Table 2. Relative sensitivity of functions to a change in T compared to a change in P [z]

Function	$(\partial F/\partial T)_P / (\partial F/\partial P)_T$	
	T (μm)	
	1.4	3.4
	P = 35 μm	
A_w by [Eq. 1]	18.7	4.01
H by [Eq. 3]	18.7	4.01
M by [Eq. 5]	-25.0	-10.3
Mic by [Eq. 8]	149	13.1
	P = 60 μm	
A_w by [Eq. 1]	36.6	11.4
H by [Eq. 3]	36.6	11.4
M by [Eq. 5]	-42.9	-17.6
Mic by [Eq. 8]	499	63.8

[z] F= function given by Eqs. 1, 3, 5, or 8; T = wall thickness, P = perimeter, A_w = wall area (μm), H = fineness (*mtex*), M = maturity ratio, and Mic = micronaire.

change in P increases in the order: $A_w = H$, M, and *Mic*. Micronaire demonstrates the greatest relative sensitivity. At the same P, the ratios decrease with increase in T and, consequently, the upper end of the curves (Figures 1, 2, and 5) are more separated. Micronaire demonstrates the largest drop in relative sensitivity at constant P: at P = 35 µm, 149/13.1 = 11.4 and P = 60 µm, 499/63.8 = 7.82. Finally, at the same T the ratios increase with increase in P. Again, micronaire demonstrates the greatest changes at fixed T: 1.4 µm, 499/149 = 3.35 and 3.4 µm, 63.8/13.1 = 4.87.

To summarize the sensitivity of the four functions (A_w, H, M and *Mic*) to a change in T compared to a change in P, micronaire demonstrates the largest changes. As a consequence, micronaire is least sensitive to a change in P, especially at low T values.

Variability in Coefficients of Determination

The coefficient of determination (R^2) can be determined for nonlinear curve fitting, as well as linear functions. In this section of the paper, only linear functions are considered. The theoretical micronaire plots (Figures 5 - 7) are a family of lines. This results in variability in practical applications of R^2 between micronaire and measures of either maturity or fineness (Table 3).

In Figure 5, the x-axis variable is wall thickness. Thus, the inherent variability in R^2 is due to the weak sensitivity of micronaire to changes in perimeter. Other contributing factors are the range and distribution of T and P values as shown in Table 3. Over the full range of the variables, R^2 is 0.9561. Note that R^2 increases to 0.9608 when only the lower half of the T values is considered and decreases to 0.7719 when the upper half values are correlated. When the range of P is reduced to 45 - 55 µm over the full range of T values, R^2 is 0.9914.

In Figures 6 and 7, both axes are functions of wall area and results in a family of linear lines. The lines are well separated from each other, due to increased sensitivity of H and M to changes in perimeter. Consequently, the coefficients of determination are smaller compared to the Figure 5 values.

CONCLUSIONS

Formulas were derived to aid in understanding the functional dependence of fineness, maturity, and micronaire on the fiber's cross-sectional dimensions. All three fiber properties are combinations of wall thickness and perimeter. For each combination, there is a common term and sometimes one additional term. The common term is wall area which, in itself, is another combination of thickness and perimeter. For fineness, maturity, and micronaire, the specific combinations of thickness and perimeter are wall area, wall area divided by perimeter squared, and the ratio of wall area and perimeter, respectively.

Plots of fineness, maturity, and micronaire as a function of wall thickness give a family of curved lines each representing a given perimeter value. Also, plots of micronaire versus fineness and micronaire versus maturity ratio give a family of linear lines

Table 3. Coefficients of determination (R^2) of micronaire plots obtained when fitting a simple straight line relationship to the simulated data [z]

Figure	x-axis	Range of values (µm)		R^2
		P	T	
5	T	35 – 60	1.4 - 3.4	0.9561
			1.4 - 2.4	0.9608
			2.4 - 3.4	0.7719
		45 – 55	1.4 - 3.4	0.9914
6	H	35 – 60	1.4 - 3.4	0.6767
		45 – 55	1.4 - 3.4	0.8821
7	M	35 – 60	1.4 - 3.4	0.4876
		45 – 55	1.4 - 3.4	0.8660

[z] T = wall thickness, P = perimeter, H = fineness (*mtex*), and M = maturity ratio.

each representing a fixed perimeter.

Micronaire is more sensitive to a change in wall thickness (in µm) compared to the same change in perimeter. For immature cotton (wall thickness of 1.4 µm), the micronaire value is almost independent of perimeter. At this thickness, the model predicts a change of only about 0.20 of a micronaire unit over the perimeter range of 35 - 60 µm. For mature cotton (wall thickness of 3.4 µm), the micronaire value is more dependent on perimeter. At this thickness, the model predicts a change of 1.24 micronaire units over the same range of perimeters.

Coefficient of determination plots of the simulated data are confounded by the family of lines in the plots. If a simple linear model is applied to the simulated plots of micronaire against fineness, then the R^2 ranged from 0.68 to 0.88. If a linear model is applied to the simulated plots of micronaire against maturity ratio, then the R^2 ranged from 0.49 to 0.87. Micronaire is not a good substitute for maturity in the simulated data.

It is inevitable, from the perspectives of both textile science and the industry, that interest will remain high in micronaire-fineness-maturity relationships. This paper sets the stage for the experimental evaluation of the relationships (Part II of this series).

DISCLAIMER

Mention of a trademark, warranty, proprietary product or vendor does not constitute a guarantee by the U.S. Department of Agriculture and does not imply approval or recommendation of the product to the exclusion of others that may be suitable.

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