FINENESS/MATURITY RESULTS FOR THE LATEST GENERATION OF AFIS

M. Dean Ethridge, Ph.D., Director
Eric Hequet, Assistant Director

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Introduction

This is a progress report on a comparative analysis of the fineness/maturity measurement in the latest generation AFIS machine at the International Textile Center. Comparisons are made with other measurements that also capture information related to fineness and maturity. These are the following:

- HVI micronaire
- FMT micronaire
- FMT maturity ratio
- FMT fineness
- AFIS diameter (from older generation AFIS)

Comparisons are also extended to the predictive power of fineness and maturity measurements on the levels of fiber bundle strength and yarn strength. This is done for yarns spun both on the ring spinning system and on the open-end rotor spinning system.

Comparisons among the fiber measurements come from a sample of 191 Upland and extra long staple (ELS) cottons from over the world. For analysis related to the spun yarns, the results were taken from a subset of 66 cottons, with all of these being Upland type cotton. The limited number is only because spinning tests are not completed; these tests are now in the process of being done.

Correlations Among Fiber Variables

The correlation matrix for the fiber measurements on the different instruments is shown in Exhibit 1. As we would expect, the correlation between the two micronaire measurements, the HVI versus the FMT, is quite close to 1.0 (at 0.97). Also, when we regressed one upon the other, the regression line has a slope very close to one and an intercept very close to zero. Of course we know that micronaire is an ambiguous estimate of fineness and maturity combined; therefore, it is imperative that we develop measurements that separate fineness and maturity with adequate precision.

Exhibit 1. Correlation Matrix for Fiber Measurements

		HVI	FMT			Old AFIS	New AFIS	
		Micronaire	Micronaire	Mat. Ratio	Fineness	Diameter	Fineness	Mat. Ratio
HVI	Micronaire	1						
FMT	Micronaire	0.97	1					
	Mat. Ratio	0.74	0.73	1				
	Fineness	0.71	0.73	0.14	1			
Old AFIS	Diameter	0.45	0.43	0.01	0.67	1		
New AFIS	Fineness	0.72	0.71	0.34	0.74	0.83	1	
	Mat. Ratio	0.59	0.60	0.70	0.16	- 0.27	0.24	1

It is also seen in Exhibit 1 that the micronaire values are highly correlated with FMT maturity and fineness and with new AFIS fineness; all correlation coefficients are above 0.7. The micronaire correlations with new AFIS maturity are somewhat lower, at about 0.6. But the correlation coefficients between micronaire and the old AFIS diameter measurements are low, at 0.45 and 0.43.

Comparing the three fineness measurements (FMT fineness, old AFIS diameter, and new AFIS fineness) reveals that the correlation among them is high: 0.67 for diameter versus FMT fineness and a notable 0.83 for diameter versus AFIS fineness. The Correlation between FMT fineness and AFIS fineness lies between these two, at 0.74. Somewhat lower still is the correlation between the two maturity ratio measurements from the AFIS and FMT, at 0.70.

As we would expect with a global sample of cotton, none of the statistical correlations between maturity ratio measurements and fineness measurements are significantly different from zero (Exhibit 1). The diameter measurement is almost perfectly uncorrelated with FMT maturity and is negatively (but insignificantly) correlated with AFIS maturity.

The diameter measurement has always seemed to be a conceptually important one. While we do not know exactly what measurement is being captured by the AFIS, if the diameter measurement is truly connected with the theoretical diameter of the cotton fibers, then it should be a powerful predictor of textile performance of the fibers.

Use of Standard Fineness

At the ITC we are applying the concept of "standard fineness"—defined as the ratio of fineness to maturity ratio. It is well known in scientific circles that a cotton fiber's diameter and perimeter are proportional to its standard fineness. Of strategic concern, however, is just how well the measuring instruments are capturing any of these concepts.

Of course we can derive estimates of standard fineness from measurements of fineness and maturity ratio with the FMT and the new AFIS. This was done, and the resulting correlations between these standard fineness estimates and the other fiber measurements are summarized in Exhibit 2. None of the correlations associated with the FMT measurements of standard fineness are noteworthy; indeed, they are

Exhibit 2. Correlations Between Standard Fineness Measurements and Other Fiber Measurements

		FMT Standard Fineness	New AFIS Standard Fineness
HVI	Micronaire	-0.09	0.16
	Micronaire	-0.08	0.14
FMT	Mat. Ratio	-0.70	-0.25
	Fineness	0.59	0.50
Old AFIS	Diameter	0.47	0.91
New AFIS	Fineness	0.25	0.66
	Mat. Ratio	-0.44	-0.57

impossible to interpret. For the new AFIS, however, the correlation of 0.91 (shaded cell in Exhibit 2) with the old AFIS diameter measurement immediately caught our attention. As we might expect after seeing these correlations, the correlation between FMT standard fineness and AFIS standard fineness is not high, at only 0.55. We are led to the conclusion that one of these measurements must be wrong; it is possible that they both are wrong, but one of them must be.

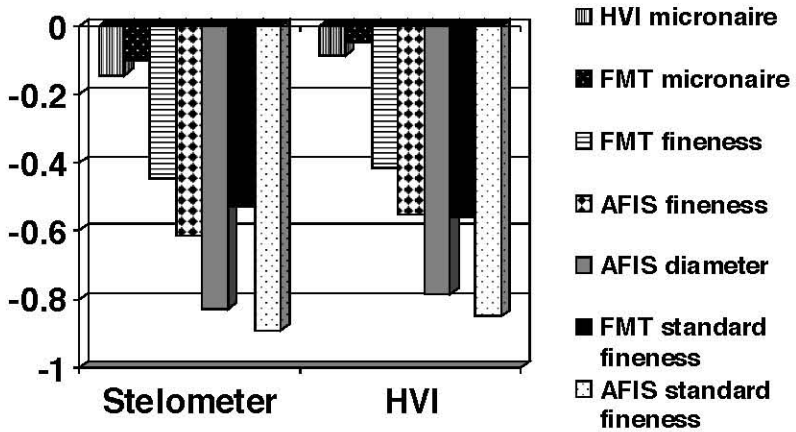
Predictive Power of Fiber Fineness Measurements

In order to assess the "relative correctness" (or at least the usefulness) of the available fineness measurements, we may look at their ability to predict fiber bundle strength and yarn strength. For fiber bundle strength, we know that factors affecting it include: individual fiber strength, individual fiber elongation, the number of fibers in the bundle, etc. Also, we know that, for a standardized bundle weight, the linear density of the fibers enables an approximation of the number of fibers in the bundle. Therefore, we can conclude that fiber fineness will correlate well with bundle strength. The correlation between fineness and bundle strength will be negative, because as fibers exhibit less fineness, the numerical measure increases, the number of fibers in the bundle decreases, and the strength of the bundle decreases. Therefore, all measurements reflecting fiber fineness should have a correlation with fiber bundle strength between zero (implying no correlation) and a minus one (implying perfect correlation). The correlations of various fiber fineness measurements with the fiber bundle strength measurements from the Stelometer and the HVI are summarized in Exhibit 3.

Micronaire measurements from the HVI are poorly correlated with both Stelometer and HVI measurements and the FMT micronaire measurements are even worse (Exhibit 3). The FMT fineness is still quite poor at only about –0.4 for either the Stelometer or the HVI. The AFIS fineness is somewhat better but still with an absolute value at about 0.6 or less.
The diameter measurement from the old AFIS gives us a quantum improvement in correlation, to approximately –0.8 for both the Stelometer and the HVI (Exhibit 3). Clearly there is something useful in the AFIS diameter measurement.

Moving on to the standard fineness measurements, we find that the correlations for FMT standard fineness are somewhat improved over those for the unstandardized FMT fineness, but they are still poor (Exhibit 3). We are left with the conclusion that, whatever the FMT is measuring, it is not capturing the essence of fiber fineness.

Exhibit 3. Correlation Coefficients: Fineness Measurements vs. Bundle Strengths



When we consider the standard fineness taken from the new AFIS, we are given a pleasant surprise. We achieve correlations with the Stelometer and HVI bundle strength measurements that are slightly higher than even for the diameter measurement from the old AFIS (Exhibit 3). These results appear very worthwhile; they should encourage the further development and application of the standard fineness measurement that may be derived from the new AFIS.

Yarn strength is an ultimate objective for textile manufacturing. We know that factors affecting yarn strength include: individual fiber strength, individual fiber elongation, the number of fibers in the yarn cross section, the yarn count, the yarn structure, the friction forces among the fibers, etc. Since there are additional, major parameters involved in yarn strength, we would not expect that the levels of correlation with fiber fineness measurements to be as high as they are for fiber bundle strength. Nevertheless, the correlations should be important because, for a standardized yarn cross section and for a given yarn structure, the linear density of the fibers will determine the number of fibers in the cross section.

Representative results are shown for two yarn structures (from ring spinning and open-end rotor spinning systems) and for two yarn counts (36 Ne on the ring system and 28 Ne on the rotor system). The results for these two yarn counts are quite consistent with results from other sizes.

A chart of correlation coefficients generally confirms our expectations for lower correlations among fineness measurements and yarn strengths (Exhibit 4). It also reveals the same general pattern of behavior among the alternative fineness measurements that were observed in Exhibit 3. Both micronaire measurements produce very low correlations and both of the fineness measurements are also disappointingly low. But the old AFIS diameter measurement again produces a remarkable jump in correlation (reaching -0.7 for the ring yarn and -0.6 for the rotor yarn.) Finally the FMT standard fineness again fails to correlate well, while the new AFIS standard fineness is again the star performer (reaching –0.8 for the ring yarn and –0.7 for the rotor yarn).

Conclusion

These results suggest that more attention should be focused on the meaning and measurement of standard fineness. We are hopeful that our new AFIS will provide a platform for bringing this measurement to the forefront. Conceptually, such a measurement already embodies both the fineness and the maturity dimensions, both of which are known to be fundamental indicators of the use-value of cotton fibers in textile manufacturing.

Exhibit 4. Correlation Coefficients: Fineness Measurements vs. Yarn Strengths