CONTROLLING DEAD FIBER THRESHOLDS FOR BEST SPINNING AND FABRIC DYEING

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Cotton fiber maturity is an important property that can significantly affect textile product quality and efficiencies, for example dyeability and stop rates in the process flow. After fiber length, which governs nearly all settings in a textile plant, fineness/ maturity can be regarded as a close second in importance.

What is fiber maturity? without getting into its classical definition, it is, basically, the amount of cellulose that has been deposited in a cotton fiber's secondary wall. It is this cellulose that enables a producer to bring in a profitable crop, since it is the weight that he sells, and it is this cellulose that allows the textile spinner to produce yarns containing fewer neps and short fibers at decent efficiencies. It also allows the weaver and finisher to bring forth fabrics that will dye and finish well, and provide adequate consumer serviceability.

Traditionally, the textile industry has used fiber micronaire fineness as an indicator of the level of immature fibers present in a bale. The thinking here is that low micronaire bales contain more immature fibers than high micronaire bales. This is true to a certain extent. As a matter of fact, based on certain chemical tests to determine the level of mature cotton in a bale, fully 25% or so of the fibers in a mature ranked bale are immature. When we consider only the micronaire value, which is a composite measure of fineness and maturity, we really don't know much about the level of immature fiber.

Many of you remember the contrary 1995 West Texas cotton crop. That year, the summer was very hat, causing the micronaire level at the bottom of the plant to be high. In August and September, the weather turned cold, causing the plant to "shut down" and not "build" fiber length, strength, and micronaire. particularly in fruiting Zone¥^{2}, the youngest area of the plant. When the cold hit the Plains, it was approximately 15 to 20 days after anthesis, which is equivalent to approximately 400 DD 60's past anthesis. As a result, the fiber in Fruiting Zone¥^{2} had properties approximately equal to 90% of its mature length, 60% of its mature strength,and 50% of its mature micronaire, which is about equal to the primary wall, all of which fits into the realm of "dead" cotton. At the same time these cottons were subjected to high insect infestation. A double-whammy so to speak. Both of these situations caused the crop to be sbnormally sticky.

When Dr. Hal Lewis analyzed some of these West Texas cottons using his plant mapping technique, he found that a higher than normal percentage of the fibers in some of the sticky bales were considered to be "dead" fibers, or fibers having a micronaire value of around 2.0 or less. About 20% of these 2.0 or so micronaire fibers were thought to have occurred because of the cold weather that hit the High Plains. Even though most stripper harvesters and gins in West Texas have green boll traps that extract the very small, hard, mostly unopened highly immature bolls, a small percentage of them escape the traps and are ginned and packaged along with the more normal cotton. Because there was little or no cellulose deposition in the secondary wall of the fibers, they are mainly a very thin primary wall around a large lumen, they tended to be pasty which in turn added to the already stickiness of the cotton due to white fly secretions. Needless to say, when these cottons reached the textile plant their stickiness caused extreme loss in spinning process efficiencies, and yarn and fabric quality. The undyed neps caused by the "dead" cotton, along with the low micronaire fibers found normally in a bale, were disturbing to the weaver/knitter, finisher, and customer.

In 1996, many spinners that used West Texas cottons preciously either avoided the crop totally or were extremely cautious in their purchasing, buying mostly after much evaluation using a number of stickiness tests, for example, pH sprays or indicators, the Sticky Cotton Tester developed in France, or near-infrared, just to name a few, Although there were many successes with respect to "staying out of trouble," the nature of the tests, their procedures, and testing variabilities never really allowed one to be fully confident that a spinning plant would not experience devastating, costly poor running performance.

So, realizing that these troublesome experiences have a knock of coming around again, what can the spinner do to avoid owning cottons that contain a high level of very immature fibers that process with much difficulty, nep excessively, break easily during movement towards yarn, and do not dye to any kind of acceptable quality?

Without instruments, the methods are fairly simple. For example, a buyer con watch the weather in the areas where he buys cotton. He can tune in to his buyer peers for word-of-mouth assessment. He can go take a look. I'm sure that you can think of many more non-instrument ways, but are they fool-proof, or at least close to it, to avoid spinning problems? I think not!

Let's talk about some of the more popular fineness/maturity testers currently being used in the United States, and try to put some sort of value to the industry on them with respect to avoiding very low micronaire fibers in normal micronaire cotton bales. I suppose that in any discussion about cotton fiber maturity, the micronaire air flow resistance method for determining average relative fineness cannot be left out.

Suffice to say, the micronaire is a pretty good instrument for determining average fineness, and over the years industry has used it fairly effectively for purchasing and controlling cotton mix laydowns. But, it does not give on indication of the level or the amount of very low, immature fibers present in a bale, the ones that we as spinners wish were not there. So although good for an average fineness measurement, it cannot be used to determent immature cotton fiber levels. About as close as you can come using the micronaire procedure is that, within a variety, the lower the micronaire the more apt you are to have "dead" cotton fibers present. It is cautioned here that there are some varieties being grown that are considered to be mature even at lower than "normal" micronaire levels.

The Shirley FMT is a popular instrument for measuring cotton fiber fineness and maturity. Nearly 300 of them exist world-wide. The FMT (fineness and maturity) correlation with micronaire only average levels of each property are possible. So, it has the same disadvantages as the micronaire when trying to avoid relatively high levels of low micronaire, "dead" fibers in normal micronaire level bales.

Well, what's left? The Institute of Textile Technology has been working for quite some time on measuring cotton fiber maturity using near infrared (NIR). Although there are a few skeptics concerning measuring maturity using NIR. we feel comfortable with the method. In its development we used a number of cotton, world-wide and domestic, to train, if you will, the NIR maturity instrument to correlate with USDA microscopic maturity, where we achieved a correlation coefficient of 0.97. Additionally, we obtained a correlation coefficient of 0.94 with a modified FMT maturity reading using Dr. Justin Gutknecht's regression equation. The relationship that we found when correlating NIR with dye uptake, K/S, was 0.96. As a final test, we used the NIR method to evaluate E. Lord's maturity versus growth period. The NIR data tracked almost identically with

Lord's Degree of Thickening and Days After Flowering. But, as with the micronaire and FMT, again only an average maturity level can be determined. The distribution of micronaire values, which we can say track maturity, is missing.

Short of very tedious, time consuming, and expensive sophisticated testing, what then is out there that give the spinner any kind of hope that certain levels of very immature fiber in a bale can be avoided? There's only one instrument that presently comes close to being able to keep the spinner/weaver out of difficulty, the AFIS instrument by Zellweger Uster. In out work back in 1995 with the contrary West Texas crop we used the AFIS L&D module, placing emphasis on the D, diameter, measurement and its distribution. In the AFIS L&D, D is necessary for the correct calculation of the staple diagram by weight from the staple diagram by number as measured by the AFIS-L. Using six cottons we determined the relationship between micronaire fineness and micron diameter, realizing of course that there is a question of cotton fiber diameter irregularity. We assumed though that the 9.000 fibers that were measured for each cotton tested, the micron data represented the average apparent diameter, and therefore, micronaire fineness. When we plotted the data from the AFIS-D against micronaire fineness, we found an r-squared value of 0.97. With this relationship, the projected micron value for the "dead" cotton threshold 2.0micronaire was approximately 10.0microns. Analyzing five cottons having a micronaire range of from 2.79 to 7.08 we found that the "dead," 10.0 micron cotton fibers were in proportion ranging from 11.5% in the 2.79 micronaire bale sample to 2.8% in the 7.08 micronaire bale sample. The data for the five cotton's studied are as follow:

Micronaire	Fiber 2.0 Micronaire and Lower, %
2.79	11.5
3.99	10.0
4.61	8.5
5.27	4.1
7.08	2.8

Note that, based on this preliminary work done in 1995, with the realization that there is a small amount of risk associated with the measurement because of variety differences, it is possible to determine the approximate proportion of "dead" fiber in a bale of Upland cotton. If you set a level of micronaire, that for a normal crop year would not cause any undue problems with processing performance or quality,4.0 for example, and evaluate those bales that register below 4.0 micronaire for AFIS length and diameter properties, or on Zellweger Uster's L and NM for length and Maturity properties, it is possible to lessen or avoid the problems associated with immature cotton fibers by setting an acceptance limit of fibers finer than 10 microns ("dead" cotton). Presently, that limit seems to be in the neighborhood of 10.3%, which, ironically matches the 3.6 to 3.8 average micronaire bales set as the minimum particularly sensitive to immature cotton fibers form a dyeing point of view.

In closing then, spinners and fabric manufacturers should take a look at existing AFIS technology to determine if they can use it to avoid higher than normal levels of immature fiber in "average" micronaire cotton. There is a ray of promise with AFIS. At the same time, researchers should continue to focus on "dead" cotton measurement, or even better find a way to avoid it in the crop itself, so that the U.S textile industry con retain its reputation as the supplier or quality products for consumers at home and world-wide