TEXTILE topics

Volume 2004-3
Summer 2004

International Textile Center | Texas Tech University | Lubbock, Texas USA

TEXAS INTERNATIONAL COTTON SCHOOL NOW ENROLLING

The next session for the Texas International Cotton School will be held October 4-15, 2004. Time is quickly running out if you want to enroll for this session. Students attending can expect to gain a better understanding of U.S. cotton production, processing, testing techniques, and marketing systems. More information can be obtained from Scott Irlbeck, Communications Coordinator of the International Textile Center. You may e-mail him for more information at scott.irlbeck@ttu.edu or call 806-747-3790 Ext. 513. You can also visit the website: www.texasintlcottonschool.com.

NEW INSTRUMENT WILL INCREASE FABRIC TESTING CAPABILITIES

Thanks to a generous grant from The CH Foundation, the Materials Evaluation Testing Laboratory will soon be able to purchase a Universal Strength Tester. This measuring instrument will be used to test the strength across the full range of textiles including garments, curtains, upholstered fabrics, elastic, tarpaulins, seatbelts, etc. The new tester will have the capacity of measuring forces ranging from a few ounces up to 10,000 pounds. The ITC is very grateful to The CH Foundation for their continuing support over the last few years.

Sharing current research information and trends in the fiber and textile industries.

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RENEWED FOCUS ON SHORT FIBERS

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INTRODUCTION

In 2002 China announced that, effective April 2003, measurements for neps and short fibers would be used to determine the acceptability of nep levels and short fiber content in ginned cotton [6, 25]. The deadline lapsed without action being taken, but the enabling regulations remain in place.

Chinese officials said the test for short fiber content would be conducted according to its GB/T6098.1-1985 Test Method of Cotton fiber Length using Roller Analyzer. But neither the accuracy nor the repeatability of measurements using this method is accepted in the global cotton industry [6, 25]. Indeed, the consensus is that no high-volume, repeatable measurement for short fibers is currently available.

Nevertheless, there is strong consensus within the global textile manufacturing industry that a fast, reliable measurement of short fibers is needed. Textile manufacturers the world over treat both neps and short fibers as "contaminants" within the useful cotton fibers.

Issues regarding neps were addressed in the previous issue of *Textile Topics* [9]. This paper will treat the issues regarding short fibers.

NATURE OF SHORT FIBERS

The definition of "short fibers" has evolved over the last four decades. Tallant *et al.* [39] defined the "short fiber content" as the percentage of fibers with lengths 3/8 inch and shorter. Lord [27] used the percentage of fibers shorter than "half the effective length" as definition. He also introduced the percentage of fibers shorter than a fixed length (to be selected depending on the application) as a possible useful definition for some purposes. Ultimately, all definitions evolved into a single measure arbitrarily defined as the percentage of fibers less than ½ inch long (12.7 mm), and designated as the "short fibers content" or SFC [3]. The measurement may be expressed as a percent of total fibers either by weight [SFC(w)] or by number [SFC(n)], depending on the measurement instrument and on the application. While SFC(w) is commonly used by industry, research purposes are often better served by using SFC(n).

It has been increasingly accepted that the traditional, ½-inch definition is inadequate for the needs of textile manufacturers [12, 17-19, 23]. Most spinning systems can be adjusted to accommodate the "dominant long-fiber content"—which is practically synonymous with the "staple length"—of cotton. If the staple length is quite long, then the critical designation for short fiber may be longer than one-half inch. If the staple length is short, then the critical designation for short fiber may be shorter than one-half inch.

Exhibit 1 shows hand-prepared arrays of cotton fibers; part A shows an array from extra long staple (ELS) cotton and part B illustrates a medium staple (MS) cotton. Both pictures clearly reveal typical distributions of length for ginned cotton.

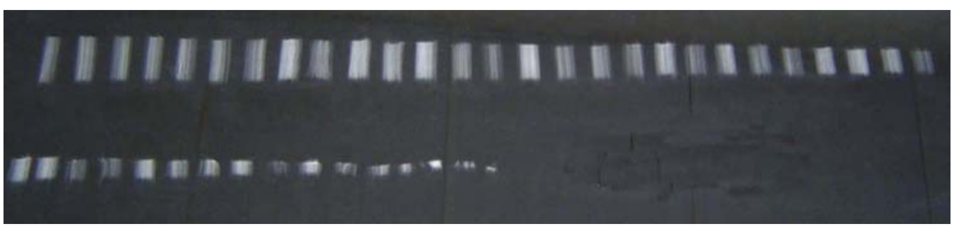

Exhibit 1(a): Cotton Fiber Samples Arrayed by Length From ELS Cotton.

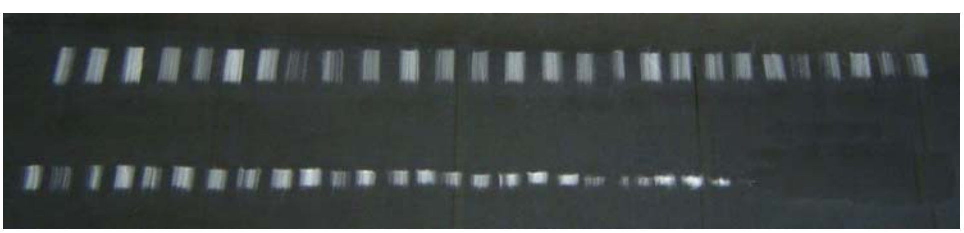

Exhibit 1(b): Cotton Fiber Samples Arrayed by Length From MS Cotton.

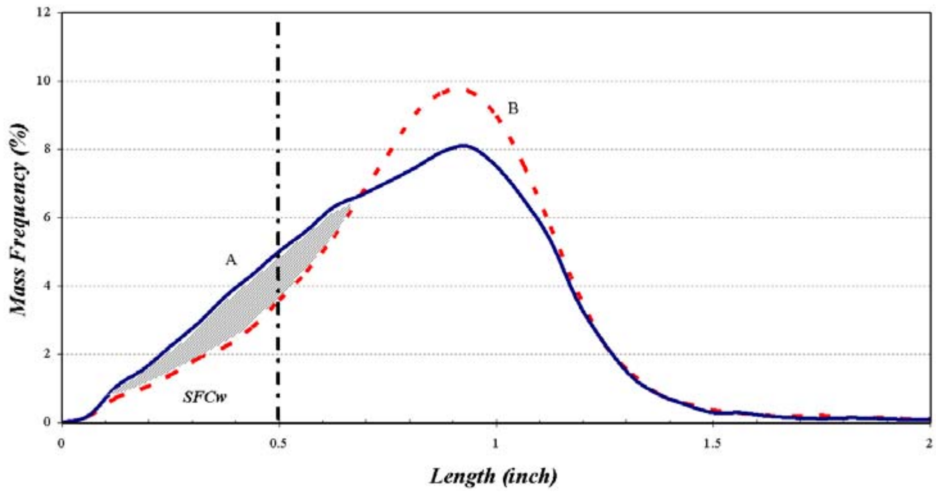

Exhibit 2: Length Distribution (by weight) of Two Cottons with Similar Staple Length.

Exhibit 2 shows frequency distributions (by weight) for the length of two similar cottons, as obtained from the AFIS®. While the staple lengths of the two cottons are approximately equivalent, sample A exhibits a larger portion of shorter fibers than does sample B (as shown by the shaded area in Exhibit 2). The shorter fibers are negatively correlated with good yarn properties (e.g., strength and elongation) and positively correlated with bad yarn properties (e.g., CV%, thin and thick places, and hairiness) [8, 13-15, 28, 37, 39].

The research focus has shifted toward obtaining information on the *entire length distribution* of the cotton being spun [14, 23]. It has long been acknowledged that, due to the numerous sources of variability in fiber length, describing a cotton sample with respect to its length is only possible by considering the entire distribution [27]. Improving the length distribution, regardless of the staple length of the cotton, will enable improved spinning performance and product quality.

If the length distribution is a heritable characteristic of cotton fibers, then cotton breeding and biotechnology programs aimed at developing new, improved cotton varieties need to incorporate the length distribution into the selection criteria. The International Textile Center (ITC) is collaborating in research efforts to establish to what extent the length distribution is heritable.

Whatever the genetic determination of length distribution, the mechanical operations in harvesting, ginning and textile manufacturing alter the distribution by breaking longer fibers into shorter ones [1, 2, 36]. There is limited information available about native fiber length distribution (i.e., on the seed). The prevailing opinion is that the amount of short fibers created by breakage is generally much greater than the genetically determined short fibers [12]. There is no evidence that the spinning performance of the cotton fibers is affected differently by broken fibers versus "genetically" short fibers.

The ultimate objectives, of course, are to produce cotton fibers with superior length distributions and to do minimal damage to the distributions during any of the mechanical operations performed on them. Achieving these objectives will require both fundamental knowledge of length distributions and reliable parametric tools to describe them. Progress is inhibited by the lack of instrumentation able to accurately measure either (1) the original, genetic length distribution of cotton fibers or (2) the evolving length distribution throughout mechanical processing of the fibers. (This is due to the *practical* impossibility of measuring the length distribution without

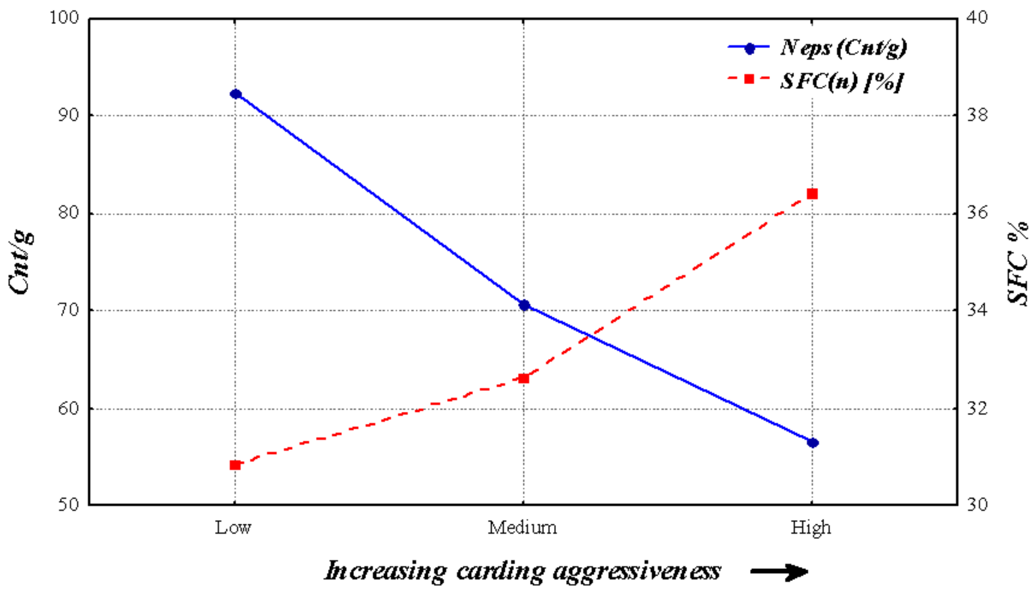

Exhibit 3: Neps and Short Fiber Content In Card Sliver, for 3 Carding Conditions with Increasing Cleaning Intensity.

altering it in the process.) Nevertheless, significant progress may be possible with careful instrument operation and interpretation of results. Research is ongoing at the ITC to develop a parametric description of fiber length distributions and express changes that occur in mechanical processes [23].

It is common knowledge that there is a strong interaction effect between neps and short fibers. One obvious source of such interaction stems from the necessity of aggressive cleaning and carding to remove elevated levels of neps and/or trash from cotton. This entails increased fiber breakage; thus, elevated SFC. This relationship is clearly shown in Exhibit 3. Optimum settings and speeds of carding machines always derive from a compromise between levels of neps versus short fibers [10, 26, 35].

Another basic reason for interactions of neps and short fibers is due to immature fibers. Not only do these fibers readily tangle up to form neps; they also readily break under any kind of mechanical stress.

MEASUREMENT OF SHORT FIBERS

Direct measurement of the incidence of short fibers must be done before yarn formation; thus, the SFC can be quantified in the raw fibers, before and after the carding, after the drawframes, and (with care) even from the roving. The effects of short fibers on the yarns may be seen only indirectly; e.g., by measuring elevated nep counts, CVs, thick places, thin places, and hairiness. Measurement technology is needed that can facilitate the minimization of short fibers both when they arrive at the mill and during the textile manufacturing processes.

The HVI®

In response to the need for a high-volume measurement of short fibers, attempts have been made to estimate them from the HVI (Exhibit 4). One approach consisted of the use of regression analysis to predict the SFC from upper-half mean length and length uniformity index [4, 7, 42]. More recent approaches are based on a derivation of the length frequency histogram from the HVI fibrogram [24, 33, 34]. The resulting "short fiber index" (SFI) is seen as a possible candidate for addition to the seven fiber properties already released for HVI-classed cotton. So far, however, evaluation results from the Agricultural Marketing Service, USDA, have not shown sufficient repeatability for inclusion in the USDA's bale classification system [5, 11, 21, 22, 30-32].

Exhibit 4: Uster High Volume Instrument (HVI)

Exhibit 5: Advanced Fiber Information System (AFIS®)

The AFIS® Instrument

The only commercial instrument in global use for measuring short fibers in raw cotton is the Advanced Fiber Information System (AFIS®, see Exhibit 5), made by Uster Technologies [40]. It also measures other fiber properties; e.g., fineness, maturity, neps, trash and dust. Since the AFIS® obtains measurements on individual fibers, it can provide quantitative data on the *distributional* behavior of the cotton fiber length (e.g., see Exhibit 2). Thus, it enables a flexible analysis of the entire length distribution.

The AFIS® presents some length measurement problems, because the fiber opener/individualizer of the instrument inevitably breaks some fibers. Also, many of the fibers passing through the instrument are not presented in a manner that enables measurement; therefore, these fibers are excluded from the results. The fiber breakage makes getting repeatable measurements among instruments very difficult, while the exclusion of various fibers from the sample raises (unanswered) questions about possible bias in the measurement results.

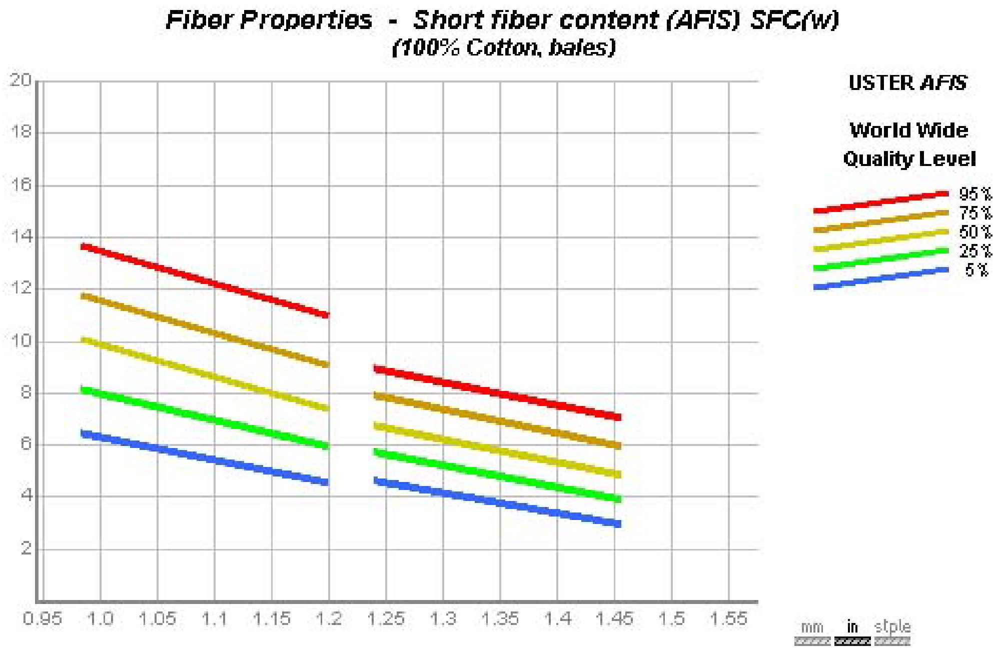

Exhibit 6: Uster Chart of World Wide Quality Levels for SFC
Source: [41]

Clearly fibers that are more susceptible to breakage in textile manufacturing are also more susceptible to breakage in the AFIS®. Therefore, the AFIS® measurements on raw fibers may correlate well with the damage done to fibers in opening and/or carding. However, the damage inflicted by the AFIS opener is sensitive to sample preparation; and especially to the degree of entanglement of the fibers. We have found that this "sample preparation effect" is important when dealing with plant breeder samples, which generally manifest a high degree of entanglement due to the lack of lint cleaning [16].

While the AFIS® instrument is being successfully utilized within textile plants to improve manufacturing processes, it is neither high-volume enough nor repeatable enough for use in the cotton marketing system. However, great care with protocols for sampling and measuring make it a useful tool in:

1. breeding and biotechnology programs aimed at developing fibers that have less short fibers, and
2. harvesting and ginning evaluations to reduce the fiber breakage in such processes.

Exhibit 6 is a reproduction from the Uster® Statistics on the Internet [41]. It shows worldwide quality levels with respect to short fiber content (SFC) as measured with the AFIS® instrument. The chart reveals, for example, that for 1-inch cotton, approximately 10.0% short fiber by weight is the 50th percentile level for SFC(w). (Thus, 10% SFC is a "normal" level for 1-inch cotton.) For 1.25-inch cotton, the 50th percentile level is approximately 6.3% SFC(w).

Other Instruments

To measure the fiber length distribution, the STI IsoTester® (Exhibit 7) simultaneously scans two fiber beards then applies image analysis [20, 38, 43], while the Premier aQura™ (Exhibit 8) scans a fiber beard using an optical LED [29]. To obtain the fiber samples, the IsoTester® uses a needle-punched bundle of fibers, with the fibers extending beyond the needle board brushed into smooth beards. The aQura™ uses an end-aligned beard of fibers taken from a sliver-like sample. (Thus, the IsoTester® approach is conceptually similar to that used by the HVI, while the aQura™ approach is similar to that used by the old Peyer instrument.) Widespread testing of these instruments has not yet been done; therefore, their usefulness is not yet established.

CONCLUSION

The research program at the International Textile Center includes a focus on the measurement and reduction of short fibers in cotton. The primary objective is two-fold: (1) develop reliable tools and procedures for exploiting information on the length distribution of cotton fibers, then (2) utilize these in improving fiber quality and optimizing mechanical processes (harvesting, ginning and textile manufacturing).

Three fundamental aspects are involved in the pursuit of this objective:

- Evaluating the existing and emerging measurement instrumentation in order to elaborate analysis protocols that reduce the impact of measurement biases.
- Expanding the knowledge base about the nature of fiber length distribution and developing parametric tools that efficiently express its features and compensate for the shortcomings experienced with the current arbitrary parameters (SFC).
- Identifying and quantifying the factors that determine length distribution, i.e., genetic/heritable factors and process-related factors.

Efforts will continue to provide a sufficiently high-volume and repeatable measure for use in international marketing. Meanwhile, the AFIS® is already a widely used tool for adjusting machinery used in yarn spinning; it can also be used to guide practices in the harvesting and ginning of cotton, in order to reduce the breakage of cotton fibers. Furthermore, it is useful for obtaining fiber length distribution data that may help to improve the genetics of cotton fibers

Exhibit 7: Schaffner Technologies IsoTester®

Exhibit 8: Premier aQura
Source: [29]

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