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NEPS IN US COTTONS

Patricia Bell
Southern Regional Research Center,ARS, USDA
New Orleans, LA

Abstract

It's vital for the US cotton industry to understand other countries' perception of our cotton quality. In the last 10 years, US mill production has dropped dramatically and international marketing is becoming critical to the US cotton producers. During this period, China's mill production and consumption of cotton has increased significantly, filling the void due to the shut down of our mills. Neps have become an international problem for US cottons, particularly in China. China has historically hand counted neps and their test methods indicate that US cottons have elevated levels of neps. US and Chinese cottons were evaluated at SRRC by the Chinese nep method and AFIS. The US samples were processed into fabrics and evaluated for white speck neps, the most critical neps for fabric quality. There is a very low correlation between the neps from the Chinese nep method and white specks. A high correlation is seen between AFIS measurements and white specks. AFIS has a mechanical opener and the clusters of immature fibers that are removed in the Chinese method become neps from the mechanical action of the opener, just as they would during mill processing. AFIS shows that the Chinese hand picked cottons have a similar level of neps as the US spindle picked cottons.

Introduction

International marketing of US cotton is much more important now than it was as few as ten years ago. As US mill production has dropped, China's mill production and consumption of cotton has increased significantly. It's important for us to understand other countries perception of our cotton quality. Neps have become an international problem for US cottons, particularly in China. China has historically hand counted neps and their test methods indicate that US cottons have elevated levels of neps. US and Chinese cottons were evaluated at SRRC by the Chinese nep method and AFIS. The US samples were processed into fabrics and evaluated for white speck neps, the most critical neps for fabric quality.

Neps

First we need to know – "What is a cotton nep?" Neps are a small knot (or cluster) of entangled fibers that appear after ginning in manufactured cotton products. In cloth, they appear as specks. In dyed cloth, the specks are usually lighter than the background (Brown and Ware 1958) and are classically considered to be of two different types: mechanical or biological neps. Recent studies have defined coalesced neps as a third and very important type.

Mechanical neps

Mechanical neps contain only fibers (Figure 1) and have their origin in the manipulation of the fibers during processing (van der Sluijs, 1999). Mechanical neps are entanglements of mature and immature fibers. Immature fibers tend to entangle easily with other fibers during processing because they are generally fine and more prone to nepping.

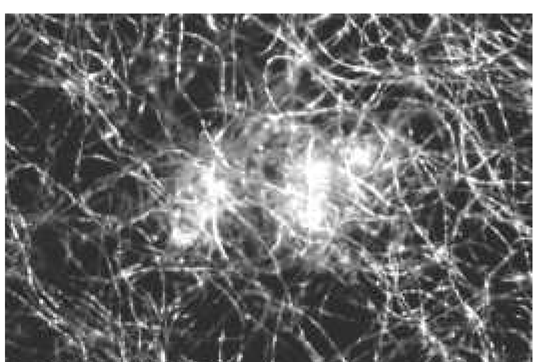

Figure 1: Mechanical Nep

Biological Neps

Biological neps contain foreign material such as leaf (Figure 2), seed coat fragments (Figure 3), motes, or stem material (Hebert, 1988). They appear as dark specks in greige fabric, and dark specks are generally removed during wet processing.

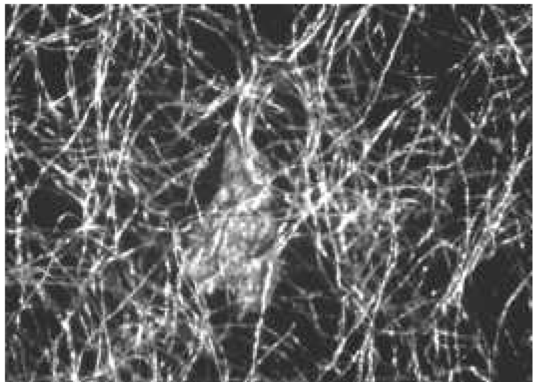

Figure 2: Leaf particle entangled in fibers as a nep.

Figure 3: Seedcoat fragment

Coalesced Neps

In coalesced neps, the immature fibers appear to have grown together in the boll. Figure 4 is a coalesœd nep composed of extremely immature fibers adhered together.

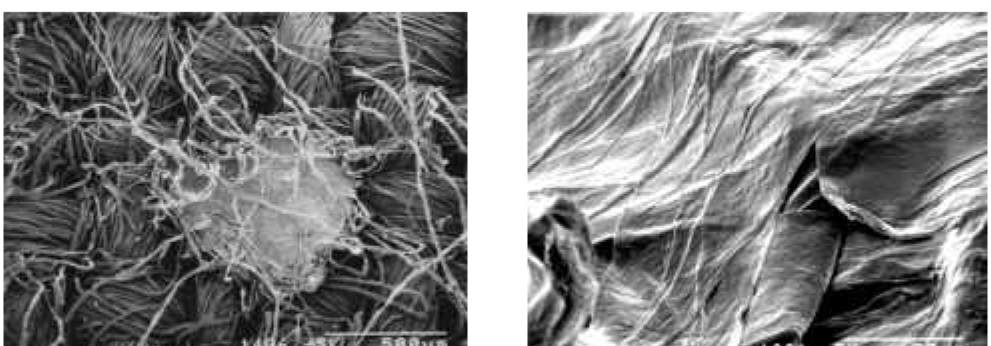

Figure 4a and 4b: Coalesced Nep (a: low and b: high magnification)

White Speck Neps

White speck neps are dyeability defects. They are the most problematic of all neps because these neps cause defects in the dyed finished fabrics as you can see in Figure 5. Neps that involve immature fibers appear as light or white spots on the surface of dyed fabrics (Hebert, 1988). Figures 1 and 4 are typical white specks. Mechanical neps are usually white speck neps, due to the nature of immature fibers easily tangling with other fibers during processing. Figure 1 shows an entanglement of mature and immature fibers that appeared as a white speck on the dyed fabric. Coalesced white speck neps, (Figure 4), are composed solely of immature fibers and always appear as white spots on dyed fabric when they survive processing to the fabric stage. Thin-walled, immature fibers have very little cellulose to hold dye and appear white in contrast to the mature fibers. They are flat and ribbon-like and thus optically reflect light, appearing even brighter. You can see how flat and reflective these immature fibers can be at high magnification of the nep, Figure 4b.

Figure 5: White Speck Neps on Dyed Fabric

China, US and Neps

Over the past few years, we have seen the US mill production (cotton use) decrease. As mill use dropped in the US, China increased their cotton mill use, production, and imports, especially from the US (Figure 6).

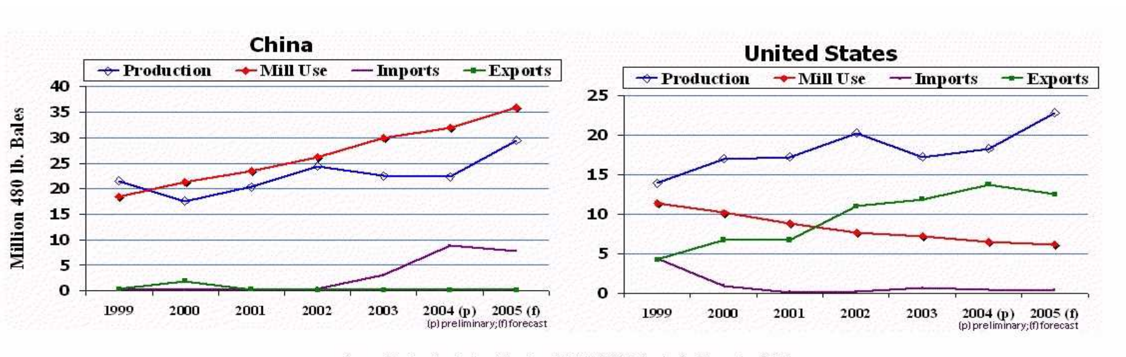

Figure 6: Production, Mill Use, Imports and Exports of Cotton for China and the US.

China's textile mills have increased their imports, especially from the US (note increased exports of US cotton in Figure 6). Therefore, it's very important to keep the channels between US and China open. The main problem is that mechanically harvested cottons (both US and Australia) are perceived to have high levels of neps and short fiber, particularly by China.

China tried to minimize their exposure to neps and short fiber by imposing minimum quality requirements. In 2002, China notified the World Trade Organization that it was going to institute new mandatory standards for short fiber content and nep count in cotton bales as measured by tests not currently used in international trade. These were standard nep and short fiber test that China has used historically. Foreign cotton suppliers would be required to submit certificates attesting that the cotton cargo had passed the two tests before being unloaded at the Chinese ports. The original proposed effective date of enforcement of these standards was April 1, 2003. Since the new tests would be time-consuming and costly and would only be required in China, they represented a potential trade barrier as these test would be require for the foreign cotton supplier's cottons.

Because United States producers were unfamiliar with these methods, the Agricultural Research and Marketing Services were tasked with examining the accuracy of the tests and feasibility of implementation of these standards. Research was conducted at USDA's Southern Regional Research Center (SRRC) in New Orleans by Patricia Bel and Dr. Leon Cui to determine the accuracy and feasibility of the Chinese test. Dr. Cui studied the short fiber measurement test, and Patricia Bel conducted the research on neps. This paper will explain the differences between the Chinese Hand Count Nep test and high speed nep tests and their relationships to fabric white specks.

Materials and Methods

U S and Chinese samples
–Five US spindle picked cottons with a wide range of fiber properties (with identical processing from field to dyed fabric).
–Twelve Chinese hand picked cottons provided by Cotton Incorporated (only had enough fiber to conduct fiber test).

Bale Fiber Test
–Fault count data obtained by the Chinese Method
–AFIS and HVI fiber test

White speck fabric test
–US control samples
–Resultant fiber to fabric relationships

The 5 US control samples were tested in fabric form for white speck as were 21 cottons from the first year of the ATMI study which has a wide range of fiber and fabric properties. The fabrics (Figure 7) range from as clean as combed cotton to very high levels of white specks.

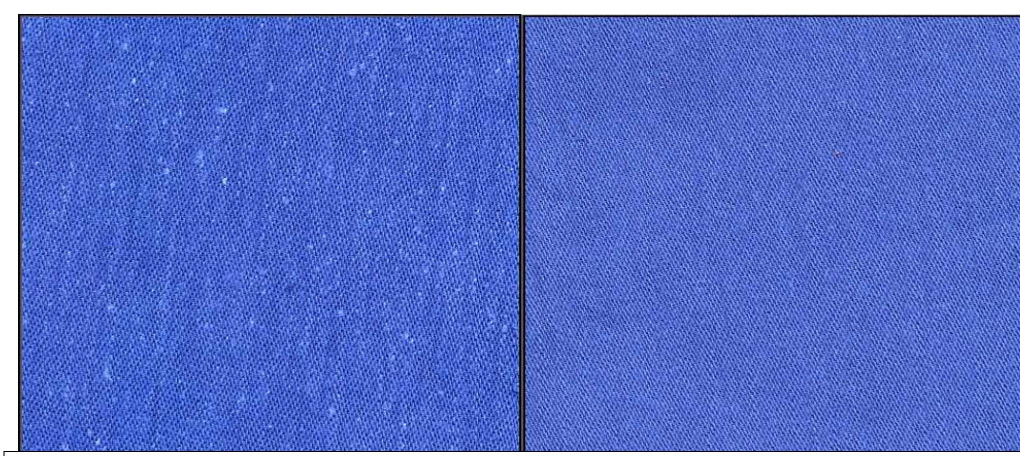

Figure 7: Fabrics with the highest and lowest levels of white specks from the ATMI study

The Chinese Nep Method

The Chinese standard outlined a two-step, hand-sorting process. First, a ten gram sample was removed from a bale sample and impurities were removed, counted, and weighed. Then from the cleaned ten gram sample, a two gram sample was taken from which neps and small seed coat fragments were counted, removed, and weighed.

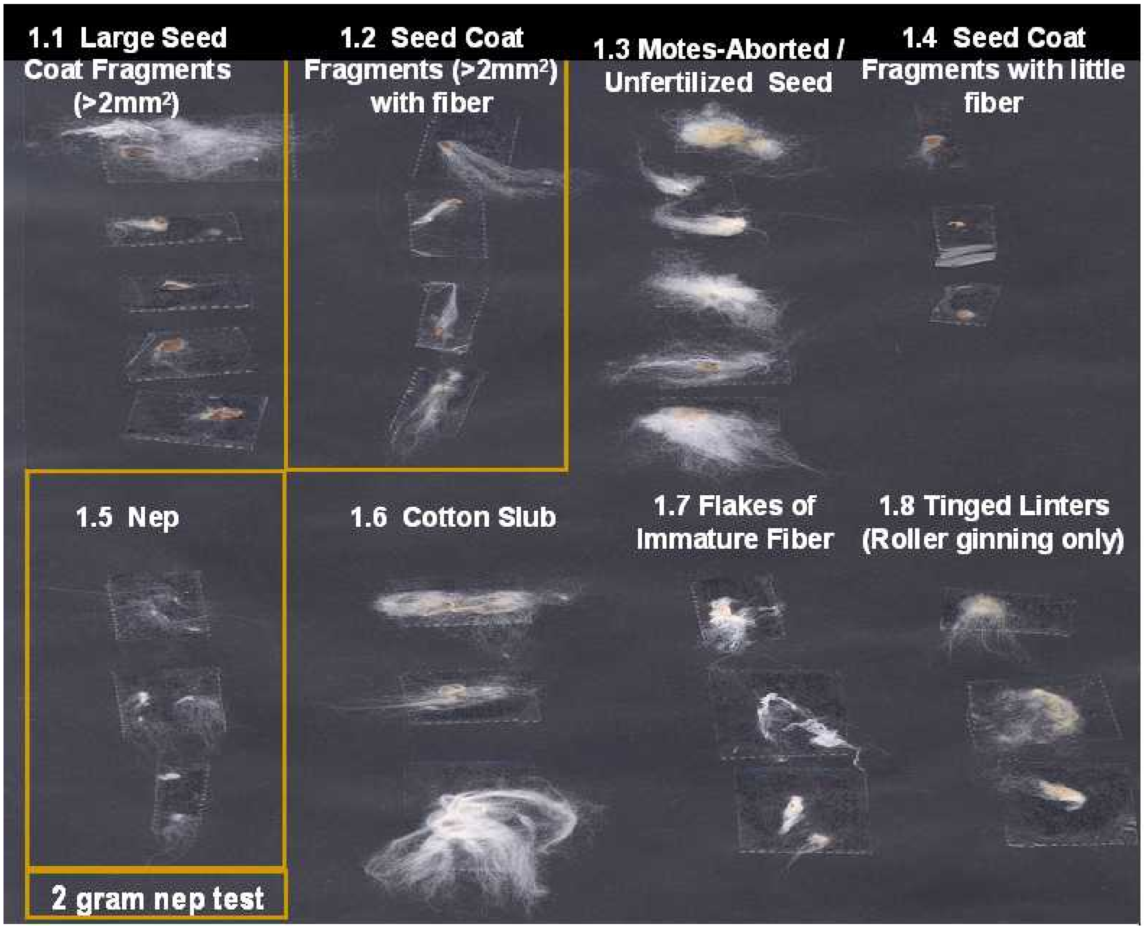

Figure 8: Defined Chinese faults in raw cotton

In Figure 8, the faults defined by the Chinese Nep Test are shown. The faults are removed from the 10-gram bale fiber sample (except 1.2 & 1.5which remain in the cleaned 10 gram sample for the nep test):

1.1 Large seed coat fragments that are under $2mm^2$
1.3 Motes-Aborted / Unfertilized Seed
1.4 Seed Coat Fragments with little fiber
1.6 Cotton Slub
1.7 Flakes of Immature Fiber
1.8 Tinged Linters (Roller ginning only)

These defects are probably the defects that the Chinese thought were removed during mill processing when the method was developed. They may well have been removed when processing was at much slower speeds. The 10 gram sample is collected from a 200 gram sample that is initially pulled from the bale. In the Figure 9 the operator is removing the faults from the 10 gram samples. The 10-gram nep test leaves in the seed coat fragments that are under $2mm^2$ and have fibers attached. It also leaves in the neps, which are the tiny knots of fibers. The Neps (1.5) and Seed Coat Fragments (SFC) (1.2) are removed in the 2gm nep test.

Figure 9: The 10-gram sample (from 200 gram bale sample) is cleaned by hand for faults (except for seed coat fragments and neps). The study is timed and samples weighed in a conditioned lab.

Figure 10 shows the actual faults removed in the 10-gram test for the 5 US Control cottons and 6 of the Chinese cottons. There is a markedly different level of motes, withmuch smaller quantities from US cottons than Chinese cottons. In addition, the immature fiber flakes are much lower levels for the US cottons than the Chinese cottons.

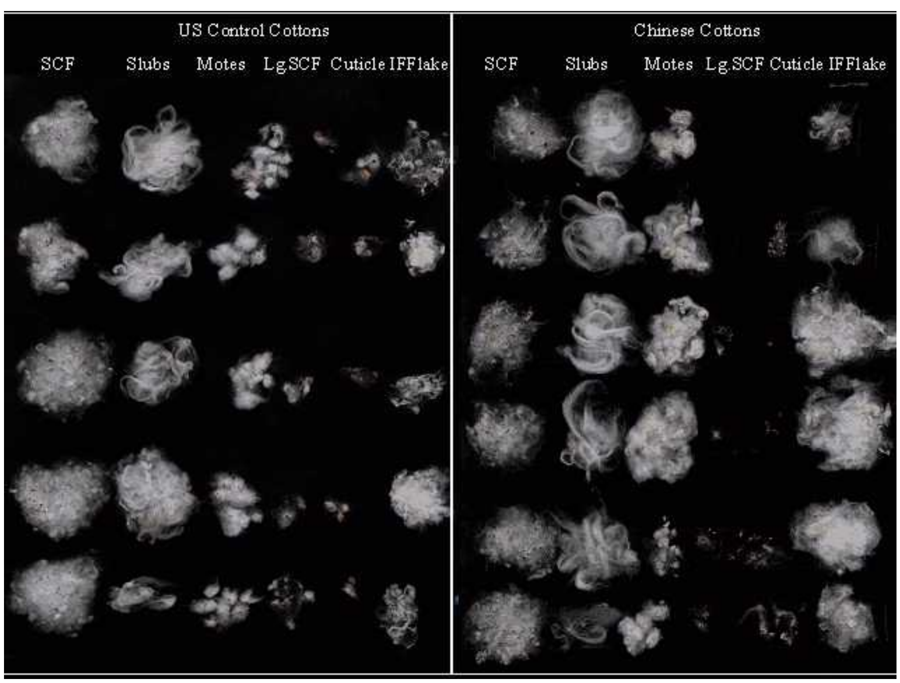

Figure 10: Actual faults removed from US and Chinese Cottons

In Figure 11, the large seed coat fragments are similar for the US and Chinese cottons except for two varieties of Chinese cotton. The unfertilized/aborted seeds, or motes, are much higher for the Chinese cottons. The cotton slubs and the immature cotton cuticle are similar for both the US and Chinese cottons.

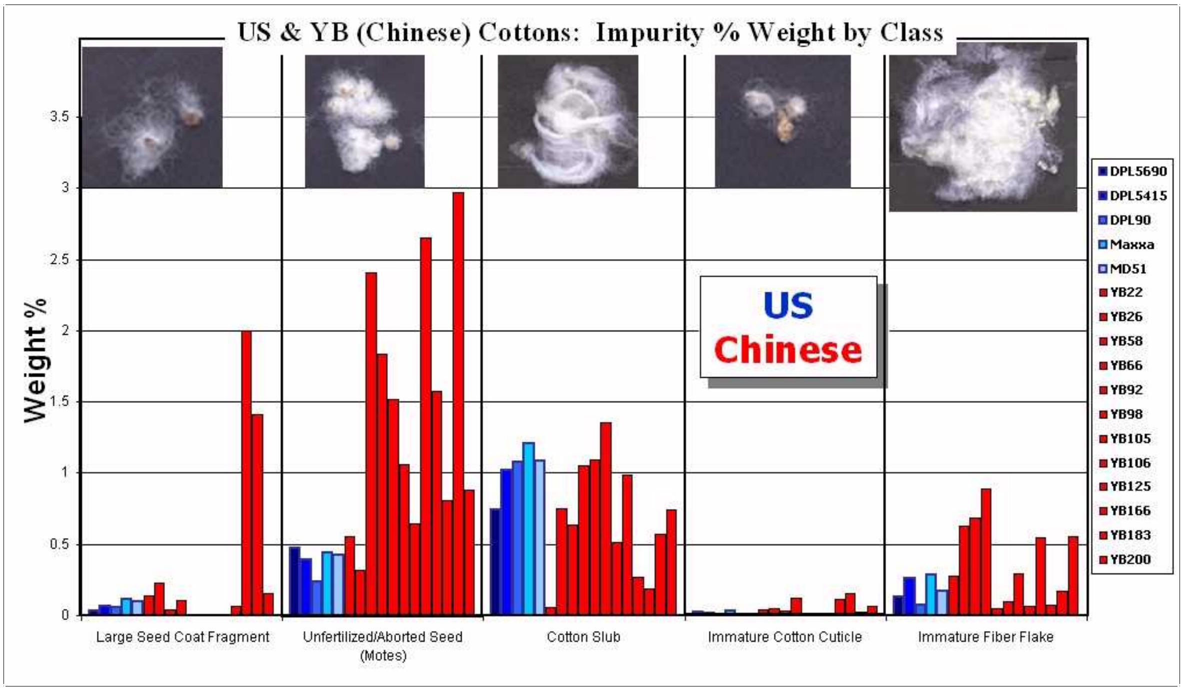

Figure 11: Faults by Class (%Weight) from the Chinese Nep Test

Immature Fiber Flake is much higher for many Chinese Cotton varieties. This becomes important because the immature fiber flakes are just that, "clusters of immature fibers that look flat and shiny." As these fibers go through mechanical processing, they become separated and opened. Because they are immature, they are more prone to nepping. The longer and finer a fiber is the more it is likely to nep during processing. This is the basis for the Buckling Coefficient, a predictor of neps, stated as UQL^2/mic^2 (upper quartile length squared divided by Micronaire squared) by Alon and Alexander (1978).

Figure 12: The 2 gram sample, from the cleaned 10g sample, is spread on velvet boards.

In 2-gram Nep Test (Figure 12), two grams of sample are taken from the 10gram sample after it is cleared of faults. The two grams are then spread on velvet boards. A pair of tweezers is used to pick out the 1.5 Nep and 1.2 Seed Coat Fragments (>2mm2) with fiber (SCF), they are counted, placed in weigh pan and weighed in a conditioned lab.

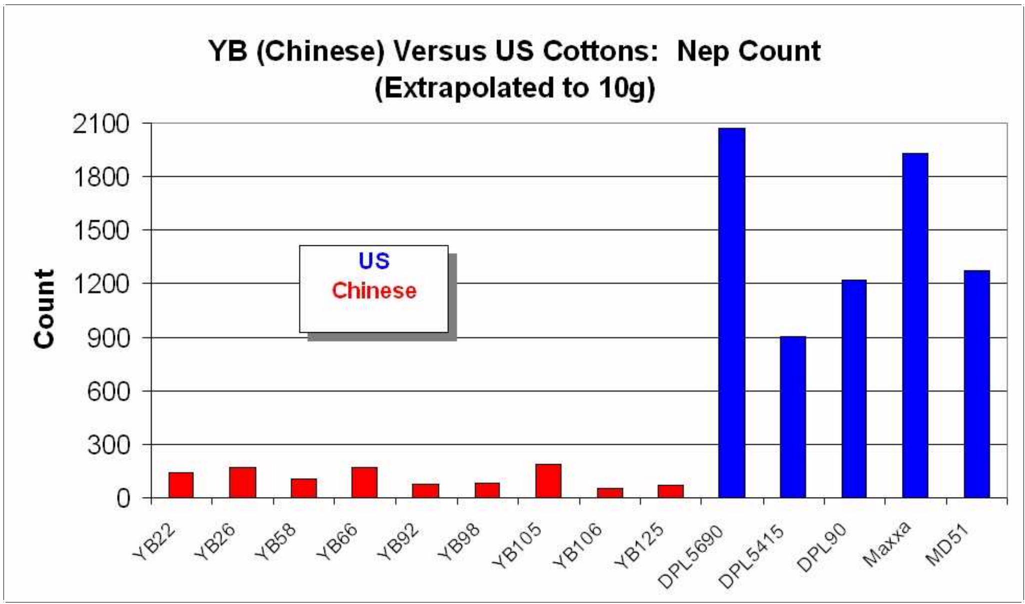

Figure 13: Nep Counts for Chinese 2-gram Nep Test

The Chinese cottons have much lower levels of neps than US cottons according to the Chinese nep method (Figure 13) and not necessarily the reality that we see in the final fabrics. Figure 7 shows the high and low white specks fabrics from the 21 varieties from the AMTI 1st year study. This was an excellent study, since there are 21 extremely different fabrics with a large range of white specks, to develop our prediction equations. The HVI prediction equation % white = 3.516 x (UQL^2/mic^2) - 0.1138, is based on the Buckling Coefficient, which means the longer and finer the fiber the more they are prone to buckling and forming neps.

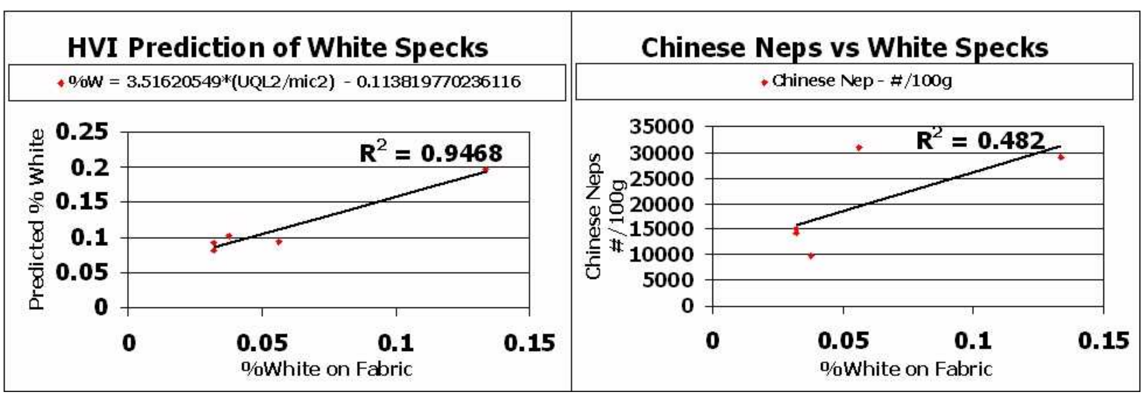

Figure 14: HVI and Chinese Nep Measurements Relation to White Speck Neps

If we use the Prediction Equation and relate the results to % White (Figure 14) for the five US control fiber and fabric we can see that white specks are predicted with a R^2 approaching 95% using the Buckling Coefficient, but the Chinese Neps related to % white is a poor predictor of white specks in the fabric (R^2 of only 0.482).

Figure 15 shows the relationships of actual % white measured on the 21 ATMI fabrics to the Predicted % White measured using several different fiber measurement systems on the corresponding fibers.

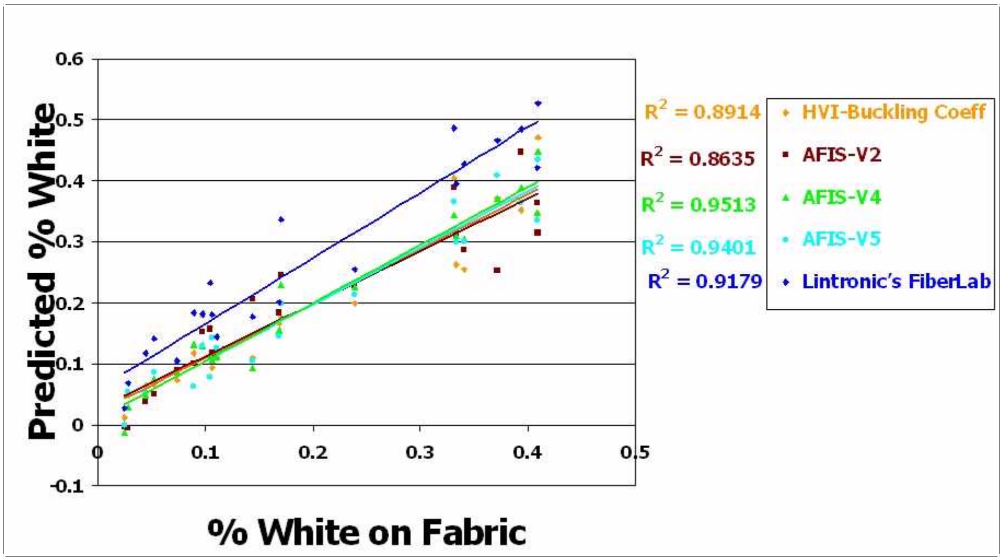

Figure 15: Predicted % White for High-Speed Fiber Measurement Systems

R-Squares for the different systems (Figure 15) show strong relationships and are as follows:

HVI using the Buckling coefficient = 0.89.
AFIS – V2 = 0.86
AFIS – V4= 0.95
AFIS – V5= 0.94
Lintronics Fiber lab = 0.92

All of these high-speed fiber measurement systems do a good job of predicting the % white on the fabric.

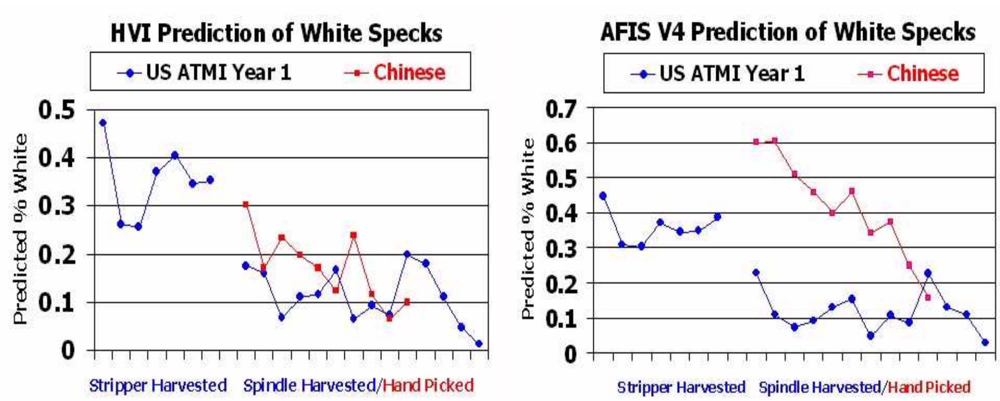

Figure 16: Predicted % White for HVI and AFIS

The predictions developed from the ATMI (21 cottons - 1st year) study to predict the % white were applied to the 12 hand picked Chinese cottons that we used in this study and plotted with the 21 US Stripper and Spindle picked cottons in Figure 16. HVI predicts US spindle picked cottons should produce the same level of white specks as the hand picked Chinese cottons. Stripper picked cottons have a higher level of immature cottons resulting in higher levels of white specks as can be seen in both the AFIS and HVI predictions. AFIS predicts higher levels of white specks in the Chinese cottons, ranging in very high range of % white, higher than some stripper picked cottons, all the way down to some of the better cottons in the spindle picked cottons. Now the question is: "Is this due to the high levels of immature fiber clusters being turned into neps as they are mechanically opened by AFIS?" It may well be, and this is probably why AFIS Nep is a strong predictor of white specks. The AFIS has opening system that it acts very much like the mechanical opening in the card. So it would individualize these big clusters of immature fibers, the Chinese immature fiber flake, and tangle them into neps. Even though immature fiber flake is not counted in the Chinese nep test, many will be separated into individual fibers in the opening line and in the card. With high speeds, these immature fibers will probably entangle with other fibers or on themselves creating neps and ultimately white specks (they have very little cellulose and they won't dye properly).

Chinese Nep Test Conclusions

The Chinese Nep Test is extremely time consuming. It took our operators approximately 8 hours per test, so it would be a very costly test to perform even at half the time. It indicates that the US cottons have higher levels of neps than the Chinese cottons, but it's not a good indictor of the white speck neps in the final fabrics. Evaluation of the method indicates that one element, Immature Fiber Flakes, which are removed before nep are counted, is the missing link in the Chinese evaluation neps. The immature clusters of fibers removed in the Chinese nep test are significantly higher for the hand pick cottons as compared to the mechanically harvested cottons, but once these immature clusters hit the mill they will turn into neps, specifically white speck neps in the dyed fabrics. The Chinese method of evaluating neps skews the data in favor of hand picked cottons. This is because hand picked cottons have seen very little mechanical processing so the immature clusters of fibers have not been separated. Immature Fiber Flakes in the US cottons have already been exposed to mechanical processing in harvesting and ginning, which separates and tangles the immature fibers into neps. Immature Fiber Flakes in the Chinese bale cotton will also be separated and tangled into neps as the fibers are mechanically processed in the mill. The remainder of those fiber flakes in the bale (mechanical or hand picked) will be opened in the mill and turned into neps, but because the Chinese cottons have a much larger fiber flake going into the mill that's when their nep levels will increase. A high correlation is seen between AFIS measurements to white specks. AFIS has a mechanical opener and the clusters of immature fibers that are removed in the Chinese method are turned into the neps, just as they would be during mill processing. AFIS shows the Chinese hand picked cottons have a similar level of neps as the US mechanically picked cottons.

This research was critical to gaining Chinese officials' commitment to internationally recognized standards and testing methods that are important to the U.S. cotton industry. The Chinese government has postponed implementation of the new standards and on December 17, 2003 announced that the Chinese cotton classification system will be reformed. This reform will not only help China modernize its classing system, but also facilitate the export of U.S. cotton.

The reform will decrease the number of classing offices from 172 to 110. Acquisition of 330 to 340 HVI systems will be necessary to carry out the fully reformed classification function. Currently, 23 HVI systems have been purchased from Uster Technologies and have been distributed among the first facilities to be reformed. Uster Technologies, manufacturer of the USDA and China HVI systems, has provided the 720 Uster Nep Tester nep measurement module on the equipment China purchased.

Uster Nep Tester Evaluation

We evaluated the Uster 720 Nep Tester and related the % white on fabric to neps per gram (Figure 17). The 720 Nep Tester had a R^2 of 0.90, AFIS Version 4 had a R^2 of 0.90, AFIS Version 5 had a R^2 of 0.92, AFIS Pro had a R^2 of 0.94, AFIS Pro with hand blended sampled had a R^2 of 0.93.

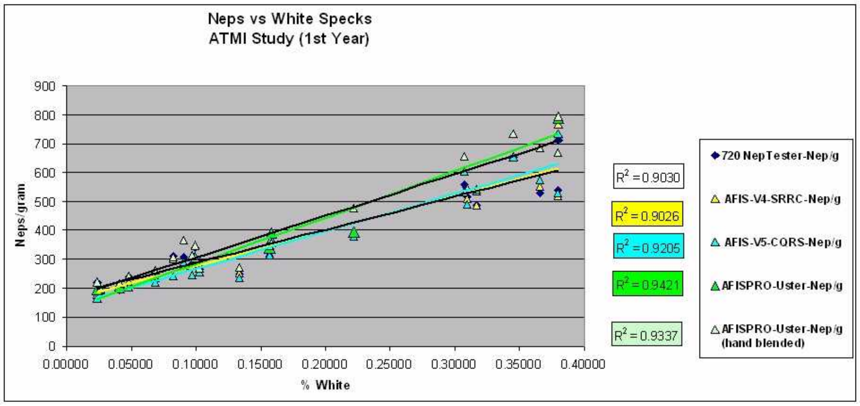

Figure 17: Uster Nep Testers

AFIS and Uster Neps have shown a strong correlation to US cottons to white speck neps, which are the most problematic of all neps, but testing presently cannot take place in a high volume environment.

Current Grading Systems and White Specks

•AFIS and Uster Nep Tests are fast but not as fast as HVI.
•The HVI Buckling Coefficient (Length^2/mic^2) indicates that long fine immature fibers are more likely to produce white specks.
•720 Uster Nep Tester (Chinese HVI add-on) and AFIS Neps have a high correlation to white speck neps in dyed fabrics.
•The opener in the AFIS and Uster Nep testers separate and tangle the Immature Fiber Flakes that are left in both the US and the Chinese bale cotton resulting in neps levels similar to mill processing.
• The AFIS IFF (Immature Fiber Fraction) levels in Chinese cottons are much higher than US levels, but these fibers will likely become neps as they are exposed to mechanical processing in the mill.

Importance of USDA Working with China

It's important for the USDA-ARS-SRRC to continue their work with the Chinese. China grows about 30 percent of the world supply of cotton and spins about 34 percent of the total cotton used in the world. The U.S. is exporting about three-fourths of its cotton production. Actual U.S. shipments to China are presently over 4.8 million bales or about 27% of the U.S. crop of 18 million bales. U.S. Department of Agriculture scientists' expertise in measuring cotton quality has helped ensure continued access to China, a market worth $733 million in 2003 to U.S. cotton producers.

In October of 2004, USDA and FAS (Foreign Agricultural Service) sent a team of experts to visit China in October to share information on establishing an HVI cotton classing system. USDA efforts with China will help to assure that the USDA recognized HVI data measurements provide a seamless marketing system for U.S. cotton.

Plans

The current white speck predictions are based on the 1st year ATMI data because it had such a wide range of white specks and fiber qualities, but only includes mechanically harvested US cottons. It is important for us to expand our database to include international cottons especially hand picked and mechanically picked, with different levels of ginning. Thirty-pound lots will be processed at SRRC's mill with the same protocol from bale to dyed fabric. Fibers will be tested on HVI and AFIS Pro. Fabrics will be analyzed for white specks using AutoRate, an image analysis system developed by Dr. Xu for white speck analysis. HVI and AFIS Pro prediction for white speck neps will be developed.

Acknowledgements

I'd like to thank Leon Cui for his excellent translations of the test methods, and Dr. Bugao Xu for his efforts in developing such an accurate measurement system for white specks, this work would not have been possible without their help.

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References

Alon, Gan, and Alexander, Ernst. (1978) "Mechanism of Nep Formation", Melliand Textilberichte.

Brown, H. B. and Ware, J. O. (1958) Cotton (3rd Ed) McGraw Hill Book Company, Inc., 1958.

Hebert, J.J., Boylston, E.K., and Thibodeaux, D.P. "Anatomy of a Nep." Textile Research Journal. 1988, 58, No. 7, p. 380-382.

van der Sluijs, M. H. J., and Hunter, L. 1999. "Neps in Cotton Lint". *Textile Progress.* 28, No. 4, p.1 - 51.