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THE VARIATIONS OF COTTON FIBER PROPERTIES AND THEIR INFLUENCE ON TEST RESULTS

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Abstract

Cotton fiber properties and their variations within a bale and the effect of blending on those properties were studied. The main focus was on the short fiber content. Two bales of US Upland cotton were selected. Fibers from each bale were blended using various opening and cleaning machines. The effect of blending on the sample uniformity and the property changes were studied. The variation of the short fiber content within a bale was found to be very high which affected accuracy of the test results. The blending significantly reduced the sample nonuniformity. However, the variation of short fiber content was still high even after processing. In fact, processing further beyond the Superior Cleaner did not reduce the sample nonuniformity significantly. Instead, further processing introduced minor fiber breakage, which was manifested by the increase of short fiber content and a slight decrease of fiber length. In addition, the processing introduced more neps.

Introduction

In several meetings on “Cotton and Textile Research,” the short fiber content of cotton has been identified as one of the major concerns. The Cotton Incorporated and the Southern Regional Research Center have been collaborating to study the fundamentals of short fiber content and its measurement. We have tested a selection of cotton samples of different varieties with a wide range of fiber properties. These cottons included commercial varieties and some varieties that are still under development by breeders. They also included some HVI Calibration cottons and International Calibration Cottons. Different instruments and methods including AFIS, HVI, Peyer, and Suter-Webb Array were used to measure the fiber properties. Some of the samples were tested by four laboratories, namely, Southern Regional Research Center in New Orleans, Cotton Quality Research Station at Clemson, International Textile Center of Texas Tech University in Lubbock, TX, and Starlab at Knoxville, TN. The test results showed that the variation of measured short fiber content was much higher than that of other fiber properties, such as mean length (ML), upper-half mean length (UHM), upper-quartile length (UQL), and Micronaire. The short fiber content measured by different instruments and by different laboratories also showed much greater inconsistency than that of other fiber properties in terms of level differences and poor correlation coefficients. Many factors contributed to the problem of high variation of SFC. Through experiments and computer simulation, we have proved that the natural "nonuniformity" of cotton was one of the major factors causing the problem. Another major factor was the lack of calibration standards for the short fiber content. Although there are cotton standards for certain fiber length parameters such as UHM or span length, there is no standard for the short fiber content. Therefore, it was clear to us that we need a set of cotton samples for different laboratories and instruments to use as research benchmarks for the short fiber content.

Since the natural variation of cotton fibers is high, cotton must be appropriately blended to obtain a truly representative, homogeneous sample for reliable test results. However, the blending may actually cause some changes in fiber properties. Therefore, we selected a large stock of two full bales of US Upland cottons, processed them using various fiber opening and cleaning (commercial processing) machines. This paper briefly reports the results of our research investigations on the variations of cotton fiber properties and their influence on the test results as well as how these variations change due to blending and fiber processing. In short, these investigations seek to determine a suitable method for blending cotton to create truly representative test samples for use as research benchmarks for studies and determinations of short fiber content.

Materials and Methods

Two bales of US Upland cotton were selected from our warehouse at SRRC. They are referred to as Bale A and Bale B for convenience. A flowchart of the textile processing machines at our facility is shown in Figure 1. Each of the machines can be either included or bypassed in the processing. Different combinations of machines and processing routes were used to obtain the best results. Cotton samples were collected at different processing stages.

A total of 24 samples were collected from different locations of bale A. The bale was then blended using industrial scale cotton processing machines as follows: hopper A to an inclined cleaner (also referred to as the Superior cleaner later), to a fine opener, to reserve units (condenser and Crosfeed), and finally to a card. Samples were collected periodically at various stages of processing, namely, 5 samples at the reserve unit and 3 samples from the batt delivered to the card by the chute feed unit. Each sample was tested by HVI with 20 replications. All tests were performed at standard atmospheric condition for textile testing.

For Bale B, the cotton from the bale was processed as follows. The cotton from the bale was put into the hopper, cleaned through the inclined cleaner, opened in the fine opener, and then put through the reserve units (condenser and Crosfeed). The samples collected at condenser and Crosfeed were put back into the hopper, and processed a second time as above except bypassing the fine opener. The purpose of the second pass through the processing machines was to see if further processing could improve the sample uniformity. Samples collected periodically at various processing stages were tested by HVI with 20 replications and 10 replications on AFIS. Only the AFIS test results from Bale B are presented here for concision.

Results and Discussion

Results From Bale A

The short fiber content, upper half mean length and Micronaire values of the samples collected from different locations of Bale A are shown in Figures 2 to 4. In Figure 2, the first number in each cluster is the short fiber content, and the following number is its standard deviation. The numbers in the second line are the maximum and the minimum values. Figure 3 and Figure 4 follow the same pattern. The average short fiber content of the overall bale (24 samples x 20 reps = 480 tests) is 13.09%, with a standard deviation of 2.92, 22.3 CV%, maximum value of 22.1% and minimum value of 4.5%. The average short fiber content from different locations in the bale showed significant differences. The average short fiber content of the 20 tests from one is 16.08%, compared with 12.08% from another. This significant difference confirms the necessity to blend the cotton for creating a standard. The UHM length of the bale showed much less variation (Figure 3) than the short fiber content. The maximum UHM in the bale is 1.03 inches and the minimum is 0.99 inches as shown in Figure 3.

The results from the samples collected at each processing stage, together with their averages, are shown in Tables 1a to 1c. The samples with different numbers (such as Crosfeed 1, Crosfeed 2, etc.) were collected at different times at the processing stage. The difference in the results at each processing stage represents the variation after blending. We can see there still is more than 1.1% difference in short fiber content (by comparing the short fiber content values of Crosfeed 3 and Crosfeed 5 in Table 1a). On the other hand, the UHM and micronaire values showed much smaller differences with the samples collected at the same processing stage. The CV for the short fiber content is about 20%, while the CV is only about 3% for UHM and micronaire (Tables 1a-1c).

Results From Bale B

The summary results of AFIS tests on Bale B are shown in Tables 2a through 2e. In general, the nonuniformity of the cotton is reduced after processing. The mechanical force exerted on the fibers during processing can break fibers, thus reducing fiber length and increasing short fiber content. However, the fiber crimps may be removed and some shorter fibers may be lost during the process. Therefore, the test results (such as mean length and short fiber content) after each processing may show an increase or decrease or no change. In addition, the variation due to sample nonuniformity and any error from testing instruments also affect the test results. Therefore, the results did not always show a clear trend or pattern.

The variation of the measured short fiber content as determined by AFIS is also much higher than those of other length parameters. In terms of CV, the CV of short fiber content is 15.7% compared with 1.54 % for mean length and 2.8% for fineness. Surprisingly, the short fiber content from the sliver still showed very high variation of about 10% CV.

By comparing the bale data before and after processing, we can see that the fiber blending/processing significantly reduced the sample nonuniformity. For example, the CV of short fiber content is reduced by about 27% (by comparing the bale and Superior Cleaner Pass1 data, Table 2a). As seen, although the short fiber content variation is somewhat reduced after limited processing, any additional processing does not significantly reduce the sample nonuniformity. Instead, the additional processing introduced minor fiber breakage, as evidenced by the increase of short fiber content and the slight decrease of fiber mean length. In addition, the further processing introduces more neps. As seen from Table 2d, the number of neps per gram increased after each process stage upto carding.

It was noticed that the appearance of cotton after processing also changed. Photographs of virgin samples from the bale and the samples after the processing are shown in Figures 5 and 6. The fibers from the bale seem to be straight and in larger flocks (left of Figures 5 and 6), while the samples of the processed cotton appear to be in small pinches and many of them seem to be folded (right of Figures 5 and 6). We believe these changes were mainly caused by the saw teeth and the doffing plates of the fine opener, the manner by which the fiber tufts are compacted/collected at the condenser, and the air flow/current in the processing pipeline. There is no doubt that the sample configuration affects the sampling and, hence, the test results.

Conclusions

The variation of short fiber content within a cotton bale was found to be very high. The CV of short fiber content (from AFIS) was about 15%, while the CV of the fiber mean length was only about 1.5%. Fiber processing significantly reduced sample nonuniformity. It also reduced CV of short fiber content by as much as 27%. However, the CV of short fiber content was still relatively high even after limited processing. Additional processing beyond the Superior cleaner did not reduce sample nonuniformity significantly. Instead, it introduced minor fiber breakage, as manifested by the increase of short fiber content and the slight decrease of fiber length. In addition, the processing introduced more neps. Therefore, it is concluded that, for the purpose of establishing cotton standards for short fiber content, the fiber blending process should not go beyond the Superior cleaner stage.

References

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Table 1a. Short fiber content of samples collected at different processing stages (HVI on Bale A).

	Average	Std. Dev.	CV%	Max	Min
Avg. Bale	**13.09**	**2.92**	**22.31**	**22.1**	**4.5**
Crosfeed 1	15.70	2.84	18.09	20.4	8.6
Crosfeed 2	14.81	2.88	19.45	20.4	9.9
Crosfeed 3	14.77	3.74	25.32	21.0	7.2
Crosfeed 4	14.67	3.39	23.11	22.5	10.2
Crosfeed 5	15.93	2.33	14.63	21.3	11.8
Avg. Crosfeed	**15.17**	**3.06**	**20.17**	**22.5**	**7.2**
Chute 1	16.32	3.70	22.67	24.2	8.5
Chute 2	15.71	3.08	19.61	19.9	8.4
Chute 3	15.47	2.90	18.75	21.0	9.5
Avg. Chute	**15.83**	**3.21**	**20.28**	**24.2**	**8.4**

Table 1b. UHM length of samples collected at different processing stages (HVI on Bale A).

	Average	Std. Dev.	CV%	Max	Min
Avg. Bale	**1.01**	**0.04**	**3.96**	**1.42**	**0.67**
Crosfeed 1	0.98	0.02	2.24	1.02	0.93
Crosfeed 2	1.01	0.03	2.88	1.06	0.95
Crosfeed 3	0.99	0.03	2.63	1.04	0.93
Crosfeed 4	0.99	0.03	3.23	1.10	0.95
Crosfeed 5	0.99	0.04	3.53	1.09	0.95
Avg. Crosfeed	**0.99**	**0.03**	**3.03**	**1.10**	**0.93**
Chute 1	0.99	0.03	2.62	1.04	0.95
Chute 2	1.00	0.03	3.11	1.05	0.94
Chute 3	1.00	0.02	2.31	1.04	0.96
Avg. Chute	**1.00**	**0.03**	**3.00**	**1.05**	**0.94**

Table 1c. Micronaire of samples collected at different processing stages (HVI on Bale A).

	Average	Std. Dev.	CV%	Max	Min
Avg. Bale	**4.01**	**0.12**	**2.99**	**4.44**	**3.22**
Crosfeed 1	4.03	0.11	2.73	4.43	3.93
Crosfeed 2	4.04	0.07	1.71	4.15	3.91
Crosfeed 3	3.99	0.05	1.35	4.08	3.88
Crosfeed 4	4.00	0.06	1.55	4.13	3.90
Crosfeed 5	4.00	0.06	1.40	4.11	3.87
Avg. Crosfeed	**4.01**	**0.07**	**1.75**	**4.43**	**3.87**
Chute 1	4.04	0.06	1.44	4.17	3.92
Chute 2	3.95	0.20	5.04	4.06	3.30
Chute 3	4.00	0.07	1.85	4.10	3.86
Avg. Chute	**4.00**	**0.13**	**3.25**	**4.17**	**3.30**

Table 2a. Short fiber content of samples collected at different processing stages (by AFIS on Bale B).

	Average	Std. Dev.	CV%	Max	Min
Bale	6.39	1.00	15.70	8.30	4.30
Cleaner Pass 1	6.21	0.71	11.43	8.50	4.70
Fine Opener	6.55	0.75	11.49	7.80	4.80
Condenser	6.32	0.66	10.44	8.10	5.30
Crosfeed Pass 1	6.56	0.75	11.51	8.60	5.10
Cleaner Pass 2	6.68	0.90	13.46	10.30	5.40
Crosfeed Pass 2	6.15	0.35	5.62	7.00	5.60
Chute	6.84	0.77	11.28	9.50	5.40
Sliver	7.65	0.80	10.48	9.30	6.40

Table 2b. Mean Length of samples collected at different processing stages (by AFIS on Bale B).

	Average	Std. Dev.	CV%	Max	Min
Bale	1.05	0.02	1.54	1.09	1.02
Cleaner Pass 1	1.06	0.01	1.37	1.08	1.01
Fine Opener	1.05	0.01	1.25	1.08	1.02
Condenser	1.05	0.01	1.26	1.08	1.02
Crosfeed Pass 1	1.05	0.01	1.12	1.07	1.02
Cleaner Pass 2	1.05	0.01	1.29	1.07	1.00
Crosfeed Pass 2	1.05	0.01	1.05	1.07	1.03
Chute	1.04	0.01	1.10	1.07	1.01
Sliver	1.03	0.02	1.54	1.06	1.00

Table 2c. Fineness (mtex) of samples collected at different processing stages (by AFIS on Bale B).

	Average	Std. Dev.	CV%	Max	Min
Bale	156.53	4.38	2.80	166.00	147.00
Cleaner Pass 1	157.34	3.01	1.91	162.00	150.00
Fine Opener	156.70	2.59	1.66	161.00	149.00
Condenser	157.43	2.21	1.40	162.00	153.00
Crosfeed Pass 1	157.85	2.60	1.65	163.00	153.00
Cleaner Pass 2	157.23	2.49	1.58	161.00	151.00
Crosfeed Pass 2	158.55	1.76	1.11	162.00	156.00
Chute	160.03	2.53	1.58	165.00	155.00
Sliver	163.63	1.43	0.87	167.00	161.00

Table 2d. Nep count of samples collected at different processing stages (by AFIS on Bale B).

	Average	Std. Dev.	CV%	Max	Min
Bale	268.50	38.39	14.30	343.00	206.00
Cleaner Pass 1	282.30	35.67	12.64	362.00	219.00
Fine Opener	379.68	55.96	14.74	475.00	120.00
Condenser	386.18	37.99	9.84	458.00	279.00
Crosfeed Pass 1	411.23	45.55	11.08	543.00	304.00
Cleaner Pass 2	423.17	56.76	13.41	500.00	308.00
Crosfeed Pass 2	431.55	29.98	6.95	484.00	379.00
Chute	412.15	36.09	8.76	538.00	331.00
Sliver	69.95	12.00	17.16	95.00	35.00

Table 2e. Nep size (µm) of samples collected at different processing stages (by AFIS on Bale B).

	Average	Std. Dev.	CV%	Max	Min
Bale	721.18	26.93	3.73	787.00	667.00
Cleaner Pass 1	716.66	32.69	4.56	833.00	659.00
Fine Opener	703.40	23.56	3.35	771.00	663.00
Condenser	702.58	28.07	4.00	790.00	642.00
Crosfeed Pass 1	721.73	24.50	3.40	783.00	682.00
Superior Pass 2	704.50	22.46	3.19	765.00	676.00
Crosfeed Pass 2	738.70	22.75	3.08	773.00	690.00
Chute	710.28	22.83	3.21	767.00	658.00
Sliver	626.88	32.43	5.17	718.00	571.00

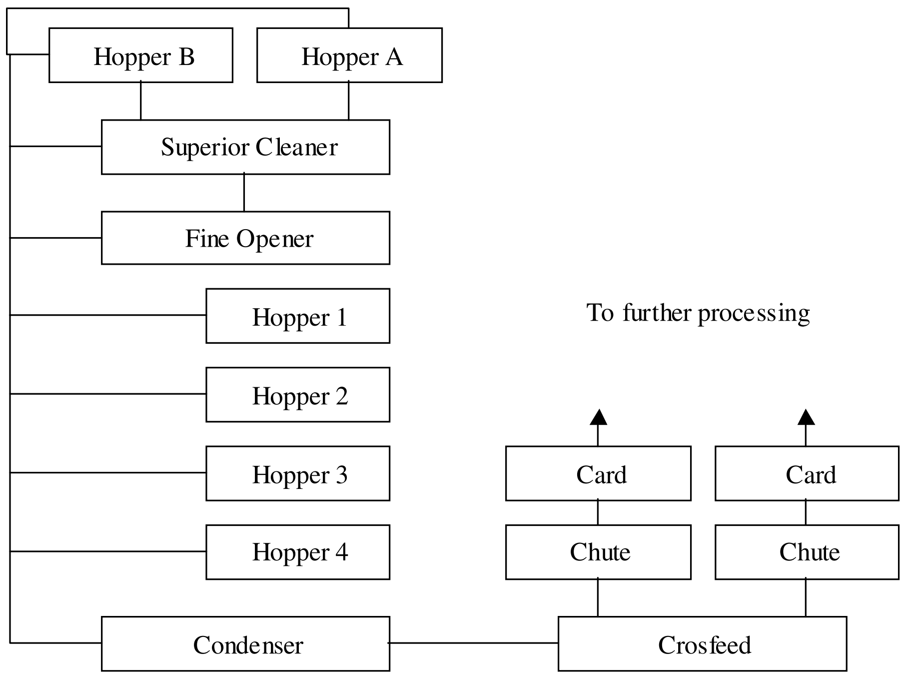

Figure 1. Textile processing flowchart.

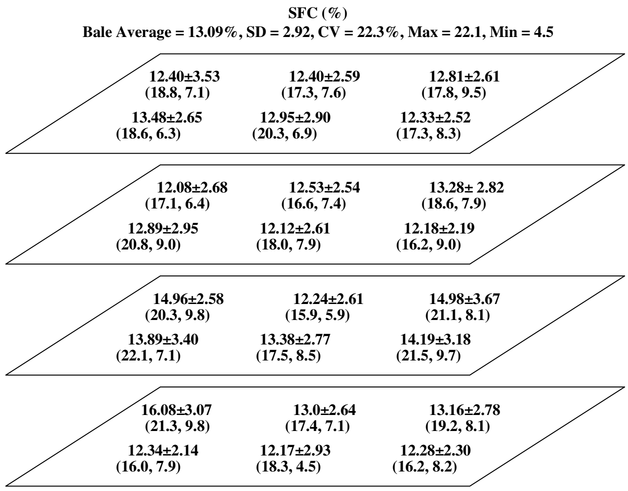

Figure 2. Short fibe content values within the bale.

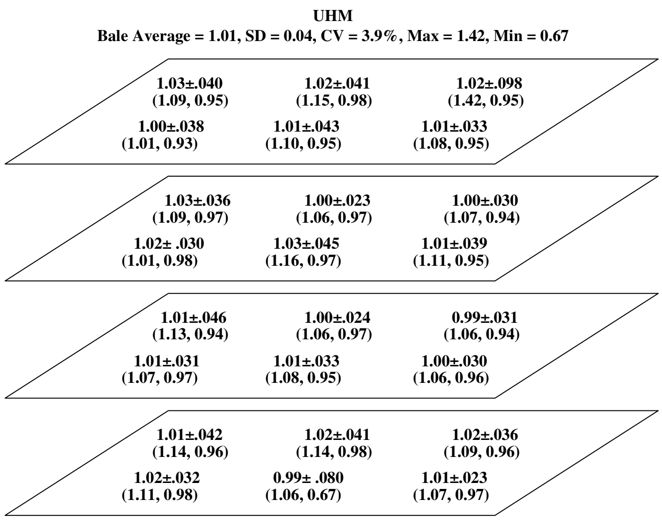

Figure 3. UHM values within the bale.

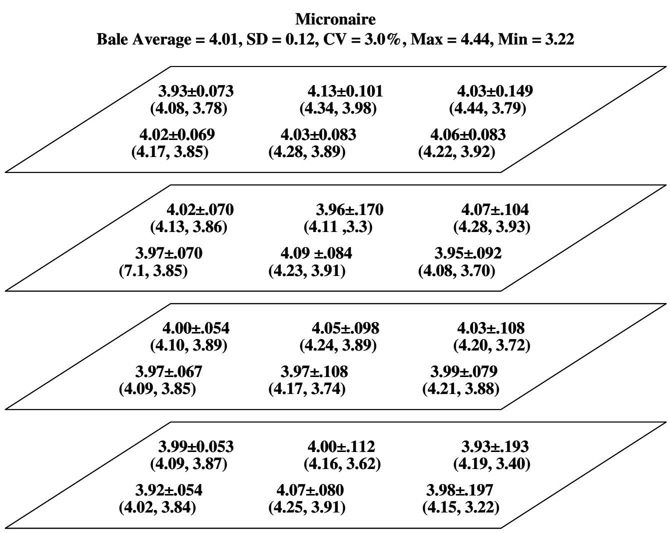

Figure 4. Micronaire values within the bale.


Figure 5. Cotton from bale (left) and from Crosfeed (right) after processing (Bale A).


Figure 6. Cotton from bale (left) and from Crosfeed (right) after processing (Bale B).