COTTON SHORT-FIBER TESTING

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Introduction

The currently available methods for measuring the Short Fiber Content (SFC) are:

Suter-Webb Array
Zellweger Uster's AFIS
Lenzing's FILE (developed in cooperation with ITV, Denkendorf)
Peyer AL-101 (currently, no longer manufactured)
Classifiber by Keisokki

Over the period of years, USDA, Cotton, Incorporated (CI), Zellweger Uster, and others have been involved in finding ways and means to measure the short fiber content using the HVI. In 1980's, Preston Sasser and Ken Bragg suggested a relationship between SFW (***S***hort ***F***iber by ***W***eight) and the length as

*SFW = k (constant) + a * (UHM) length*

*Calculated SFW = 69.1 – 1.66 * length*

1989, Zeidman, Batra and Sasser developed an equation to calculate the SFW content using the HVI data

*SFW = k (constant) + a * (UHM) length + b * uniformity*

*SFW = 122.56 – 12.87 * (UHM) length – 1.22 * uniformity*

Zellweger Uster has developed an algorithm for measuring the short fiber content using the HVI fibrogram data and this has undergone several refinements. Currently, the USDA is using this algorithm in several of their HVI instruments to measure the short fiber content of the << QC check lot >> samples. They have not been able to get an acceptable reproducibility thus far with the new algorithm.

The conventional methods used to measure the SFW (such as AFIS, AL-101 and Suter-Webb Array) are very tedious and cumbersome. If the SFW measurement using the HVI can be successfully developed and incorporated in the USDA's cotton test data, the mills would benefit more and this would add another dimension to contract negotiations (discount or premium for the higher and lower SFW). For the textile industry, the short fiber content is an important parameter for optimum machine settings as well as for the selection of bales for the laydown.

Besides, the length and uniformity, the micronaire also gives some clue about the SFW (the higher the micronaire, higher the maturity and hence, lower the short fibers and vice versa). Similarly, the strength parameter also affects the SFW – higher the strength, lower the short fiber levels (due to stronger fibers) and vice versa. As mentioned before, the Zeidman model uses both length and the uniformity in its measure of SFW.

Most of the published information on the SFC is based on limited data. Zeidman used about 1,200 data sets for his study based on USDA, Cotton, Inc. and other research data. Further, standard calibration cotton samples were used for the study.

In this paper, we undertook a study of the relationship between the HVI_SFC and the AFIS_SFC using the bales that are being consumed by our mills. Besides the Zeidman model, we also analyzed other models, such as second order.

Experimental Details

Test Protocol

A total of about 12,000 bales were sampled at random from our five spinning plants (about 2,500 bales per plant). Using AFIS (after appropriate calibration), the SFC_w, SFC_n and Neps were measured. The samples were then sent to Cotton Incorporated at Raleigh to measure the SFW using their HVI line. Their HVI line is equipped to measure the short-fiber content using Uster's present SFW algorithm.

Corresponding to each bale, the Government (USDA) test data were also pulled together. Our unique bale number sorted all the data and then arranged in the following format (all along the same line for each bale):

NT_bale_number (main identity)
USDA HVI data - gin_id, g_mic, g_l, g_u, g_str, g_rd, g_+b, g_color
CI HVI data - c_mic, c_l, c_u, c_str, c_rd, c_+b, c_color, c_elo, c_sfc_w
AFIS test data - a_sfc_w, a_sfc_n, a_neps

The first letter g_ stands for the USDA_HVI or Government data, c_ represents the Cotton, Inc.'s HVI test data and a_ represents the AFIS data. Also, c_sfc_w represents the HVI short fiber data by weight, a_sfc_w and a_sfc_n stand for AFIS short fiber content by weight and by number.

The entire study covered a period of about 3 to 4 months.

Analysis

Before any analysis, the validation of the HVI data by USDA and by Cotton Incorporated were verified by simple statistics. The frequency distribution of the individual test data for both the USDA and the corresponding Cotton, Inc. was verified. Also, the distribution of the differences between the two corresponding test values *(We did not make any attempt to separate the bales, based on whether the bale comes from Module Averaging or Single Bale tests).*

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The *t*-tests between the USDA or government data and the corresponding Cotton Inc.'s HVI data showed statistical significance (null hypothesis: no significant difference between the USDA and the Cotton Inc.'s HVI data for the corresponding bales). The USDA data represents more than one HVI instrument and also from more than one Classsing Office, but the Cotton Incorporated data came from one machine only. The statistical significance of the *t*-test could be explained due to the variability of the cotton within a bale (samples for the AFIS and Cotton Incorporated tests are totally different from the USDA bale data). Also, probably to a smaller extent, due to the differences between instruments. Secondly, the USDA testing procedure involves two different samples from a bale and reporting the average value, whereas with the Cotton Inccorporated samples, only sample per bale was used and the test data represents only one sample. For the same reason, the Correlation Coefficients (Regression Coefficients) of the g_data between the c_HVI_SFW and AFIS_SFC are very small. Measurement of SFW seems to be sample specific and hence, may require multiple tests. From a mill point of view, this small difference though significant statistically may not have any impact with respect to spinning.

The dependence of the SFW for the different cotton parameters and R-values are as follows. In all cases, the regression is against the HVI_SFW or the AFIS_SFW algorithms.

C_HVI_SFW = 97.91619 – 1.074583 * c_uniformity	R = 0.8096
C_HVI_SFW = 38.61146 – 26.25453 * c_length	R = 0.5369
C_HVI_SFW = 15.3049 – 1.271286 * c_mic	R = 0.3556
C_HVI_SFW = 15.57885 – 0.207729 * c_strength	R = 0.2220

AFIS_SFW = 8530485 – 0.0916317* c_uniformity	R = 0.3876
AFIS_SFW = 36.57671– 24.06275 * c_length	R = 0.2763
AFIS_SFW = 16.87921– 1.545023 * c_mic	R = 0.2427
AFIS_SFW = 17.33898– 0.256969 * c_strength	R = 0.1542

The Regression equation for the Zeidman model is as follows:

*Calculated SFW = 98.94211 – 10.57398 * c_len - 0.945372 * c_unif*

Calculated SFW (using Cotton Inc data) vs. c_HVI_SFW	R=0.8323
Calculated SFW (using USDA data) vs. c_HVI_SFW	R=0.4529
Calculated SFW (using Cotton Inc data) vs. AFIS_SFC_w	R=0.4032

A second order model was also tested using the corresponding length and uniformity values:

$$SFW = a * [unif]^2 + b * [unif] + c\,[len]^2 + d * [len] + e * [len] * [unif] + k\ (constant)$$

The regression equation, coefficients and the various R-values are given below:

$$Calculated\ SFW = 380.7662 + 0.23117 * [unif]^2 - 6.13035 * [unif] + 9.791743 * [len]^2 - 136.502 * [len] + 1.269662 * [len] * [unif]$$

Calculated SFW (using Cotton Inc data) vs. c_HVI_SFW	R=0.8342
Calculated SFW (using Cotton Inc data) vs. AFIS_SFC_w	R=0.4043

The second order model did not yield significant improvements in the R-values over the Zeidman model. However, USDA is working with a second order model that looks promising.

The poor correlation of the AFIS_SFW vs. the HVI_SFW may be due to the differences in the two instruments' method of SFC measurement and the associated bias and limitations. The AFIS_SFW is always higher than the HVI_SFW.

Conclusions

- The Zeidman equation matches to that of the HVI_ SFW algorithm very well and with time, the algorithm may be refined. The constant and the coefficients change very slightly from the original Zeidman equation. Higher R-values are obtained when the various parameters including the SFW are measured from the same HVI instrument.

- As expected, the UI shows the trend in the short fiber content levels.

- We feel uncomfortable in that we did not get good correlation between the HVI and the AFIS Short Fiber contents. Regression for the Short Fiber is sensitive to uniformity. Variations in the calibrations using normal tolerances may be quite all right for length and strength, but seems to affect the short fiber content. Further work is needed in this area. We are very concerned that Uster is encouraging USDA to use AFIS to correlate their HVI SFC.

- We also noticed in our tests that there is good correlation between the <<mic>> as measured by the HVI and the <<neps>> as measured by the AFIS. Neps are important criteria for the textile mills especially for ring spinning and the AFIS data would be very useful in reducing and controlling the nep contents in processing.

- We do not recommend that the USDA incorporate the measurement of the HVI_ SFW content on their data releases.

- We are providing all the relevant data to Cotton Incorporated for further work. A suggestion would be to study the effect of co-linearity between the independent variables (such as length and uniformity) and assess the extent to which the co-linearity has degraded the estimated Short Fiber Contents.

- We are in the process of analyzing the variability between the five (5) AFIS instruments within our plants as well as analysis of the data by GIN_ID to determine the variability in the cotton processing at different gins with respect to the SFW levels.

- In addition, we may be adding additional AFIS properties (from the AFIS test data) such as L_n, L_w, and UHM, 2.5 and 5.0% long fiber lengths to the data pool for additional future analysis.

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