STATUS REPORT ON SHORT FIBER INDEX AND ELONGATION MEASUREMENTS ON THE HIGH VOLUME INSTRUMENTS

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Abstract

The basic concepts behind the new short fiber and elongation measurements on the High Volume Instruments from Zellweger Uster,Inc. are reviewed. Several tests of these algorithms have been made during the last year including two large scale tests by USDA of the short fiber measurement. The USDA Candidate Calibration Bale tests gave an average CV% of 7.3% for the short fiber measurement for all HVIs. When only one HVI is used, the CV% decreased to 6.0%. This is attributed to setup differences between HVIs. The Check Lot test by USDA allowed estimation of sustainment results for short fiber measurements. For a tolerance of 1%, the actual sustainment is 79.1%. The sustainment value estimated from the standard deviation is 75.5%. Improvements in setup procedures increase this to only 78.3%. The conclusion is that the differences in the short fiber reading is much more dependent on the selection of the cotton sample than on the sample preparation and setup of the HVI.

Comparisons of elongation measurements on the HVI using the new deflection calibration and elongation algorithm with bundle stress-strain curves generated from Mantis single fiber data showed similar levels of elongation, which are approximately 5% higher than traditional stelometer values. A possible reason for this level difference may be pretensioning in the Stelometer clamps. The USDA crop samples from 1990 to 1994 were also tested using the new algorithms. This data shows that the new elongation measurement is a much better predictor of yarn properties.

Introduction

Zellweger Uster, Inc. has developed a method of deriving the fiber length distribution and thus the percentage of short fibers (less than 0.5 inch) from the fibrogram. Since this is a derived measurement rather than a direct measurement, we have referred to this measurement as the Short Fiber Index rather than simply Short Fiber. In addition, an improved method of measuring the elongation of the fiber bundle at maximum force has been developed. As the only required calibration is a purely mechanical measurement, this method has the advantage that no calibration to cottons is required. Both of these algorithms have undergone extensive testing over the past year. We will review the basic concepts underlying the algorithms and the results of these tests.

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Short Fiber Index Measurement from the HVI Fibrogram

The short fiber algorithm as developed by Zellweger Uster integrates the optical response of the fibers over the width of the lens. The first few length groups are estimated by the character of the fibrogram in the form of a quadratic since the HVI is not able to scan in front of the 0.150 in position. This allows us to calculate a complete fiber distribution from the fibrogram. This data is then treated as Suter-Webb data and various length parameters calculated including short fiber content.

The cotton set with which the short fiber algorithm was originally verified at Zellweger Uster includes international cottons collected by sales agents from around the world along with all available ICC cottons. This set of cottons was tested on two different AFIS instruments. Suter-Webb tests were performed at Zellweger Uster and at the University of Tennessee. The results are shown in figures 1, 2 and 3. The AFIS shows it usual excellent correlation (r=0.97) with Suter-Webb data. In addition, the short fiber value developed by the distribution calculated by the HVI using the new short fiber algorithm correlates well with both AFIS (r=0.93) and with Suter-Webb (r=0.94). As stated before, the entire fiber distribution is obtained. This allows us to calculate not only short fiber values but also other fiber length parameters such as the upper quartile length based on the complete fibrogram rather than a small section of the fibrogram.

USDA has evaluated the short fiber algorithm in two large scale tests. The first test involved candidate calibration bales and used four HVI lines in Memphis. The second test used ten HVIs in Memphis and involves all check lots for 1997. All ten HVIs were originally calibrated with staple standard 28.

In the candidate calibration test, a group of twenty candidate calibration bales are selected. Ten samples are pulled from each of these twenty bales along with the two calibration bales and blind labeled for a total of 220 subsamples. These are then tested on different HVIs on different days. The HVI program had been modified to generate a file recording all sample data. These files were retrieved, the sample ID crossed referenced with the bale ID, data for the same bale combined and the data analyzed. The results averaged over all lines is given in Table I. The data would indicate an average CV% of 7.3% . However, there is some difference between the levels of the different lines. The average CV% for a given line is 6.0% for all days and 5.3% for a single day.

The tests involving all check lots for the 1997 season contains over 106,000 tests. Each check lot arriving in Memphis is tested on two different HVI lines out of the ten available HVIs. The data is collected on a weekly basis and forwarded to Zellweger. Since the assignment of the checklots to an HVI line is random, it is reasonable to assume that the population of short fiber tested on each line is the same. This would imply that the average short fiber for all tests on an HVI should be the same. The averages for each line is given in Table II. These show differences of +/- 0.5% in the average short fiber value. This implies that the setup procedure could be improved. This becomes more important since staple standard 28 is no longer available. In an attempt to investigate the differences in the averages, a new setup program has been written using two cottons. Two cottons from previous 8x8s were selected by Memphis which are available in sufficient quantities. These will be tested using both Sutter-Webb and AFIS to establish values. Future installations will be made using these cottons.

The IDs for the check lot samples can be matched and the difference in short fiber values calculated. Based on these differences, a sustainment figure may be calculated for different tolerances. This is given in Table III. The distribution of the differences in short fiber values between the two HVIs used to generate the sustainment results is shown in figure 4. The mean is -0.14% with a standard deviation of 0.86%. In an effort to investigate how the setup of the HVI influences the sustainment, all short fiber results for a HVI were scaled by the average for all lines divided by the average for the HVI. This should compensate for slightly incorrect shift values due to the setup procedure. The differences were then recalculated. The distribution of these shifted differences is shown in figure 5. The mean is now very close to zero (-0.01), but there is only a slight improvement in the standard deviation (0.81%). Using these standard deviations and assuming a normal distribution, sustainment values can be estimated in both cases. These are also given in Table III. The fact that the distributions are not normal accounts for the differences in the actual and estimated sustainments. The improvement in sustainment is ~3% for the shifted data.

The relationship between the length differences and the short fiber differences in the samples is shown in figure 6 for the original data and in figure 7 for the shifted data. The conclusion is that the differences in the short fiber reading is much more dependent on the selection of the sample than on the setup of the HVI.

Improved Elongation Measurements on the HVI

Materials change shape or deform when an external stress is applied. This deformation may be extensional, such as a change in length of a column, or shear as in the bending of a beam. The ratio of the stress to strain is referred to as the modulus - the bulk modulus for compressive stresses, Young's modulus for tensile stresses and the shear modulus for shearing stress. As long as the elastic limit is not exceeded, the mechanical system returns to the original form when the load is removed. In such media, the modulus is constant. This is referred to as Hooke's Law.[1]

Deformations create errors in measuring the elongation of the fiber beard as the beard is broken. When a fiber beard is broken by an HVI, the force exerted on the jaws by the fiber beard causes the breaker system to deform. As load is applied by the fiber beard, the jaws deflect, the force transducer and the brass screws mounting it stretch and the main beam at the rear coupling the motor to the force transducer deflects. Since the traditional method for measuring the stress or displacement is the rotation of the motor, these deformations create errors in measuring the stress strain curve for the fiber beard. It is important to realize the magnitude of the distances involved in breaking the fiber beard. If the elongation is 10% and the break gauge is 3.175mm, the total travel to the peak of the curve is only 0.3175 mm. Thus a deflection of only 0.0381 mm represents a 20% error in a 6% elongation measurement. Displacement transducers mounted near the jaws have been used to directly measure the motion of jaws. However, the mechanical design of the HVI makes it impossible to attach the transducers directly to the jaws at the clamp point without comprising the mechanical integrity of the breaker system. This limitation and the small displacements and the signal to noise ratio of the transducers have limited the success of this approach [2].

The new elongation measurement involves a direct measurement of the deflection of the breaker system in the HVI by using a non-cotton medium. As this medium does not stretch within the allowed force range, the force can be related to a given deflection. An example of this is shown in figure 8. Since this allows us to calculate the true displacement, a corrected stress-strain curve can be calculated. The raw and corrected stress-strain curves are shown for staple standard 37 in figure 9.

The USDA crop samples from 1990 to 1994 were tested on HVIs utilizing this algorithm. The CVs for the new elongation measurement ranged from approximately 2% to 4%. This compares to a range of 8% to 15% using standard analysis. In addition, a valid measurement of crimp results.

As a study of the correctness of the elongation measurement, the USDA crop samples from 1990 through 1994 were tested. This represents a total of 119 samples. The samples were tested on three different HVIs. The HVIs were calibrated in both the HVI and ICC calibration modes. A total of five repetitions were tested in each mode for each sample. Thus a total of 30 tests were made on each sample. A comparison with stelometer values for the 1990 to 1994 USDA crop samples is shown in figure 10. The slope is almost unity but an offset of 5% is seen. The correlation of 0.80 compares to 0.69 for the HVI elongation data published by USDA (Motion Control Inc. HVIs). The offset between Stelometer and HVI or Mantis elongation data may be related to preloading in the Stelometer.

Independent tests show that the Stelometer elongation increases as less weight is used in pulling the bundle before clamping.

In addition, the corrected stress-strain curve has been compared with simulated bundle break curves from Mantis single fiber data. Excellent agreement is found as to level. An example is shown for an E-5 cotton in figure 11. In reality, better agreement between the two curves would be suspicious due to the difference in crimp and crimp distribution due to sample preparation. The stress-strain curve depends not only on the distribution of strength and elongation for the fibers which are broken but also on the distribution of crimp. As the brushing force in the HVI is changed, the stress-strain changes slightly. It is extremely difficult at this time to duplicate the distribution of crimp in the HVI with Mantis data.

The ultimate usefulness of any data is its value as a predictor. The simple correlation of the USDA and HVI elongation with yarn elongation data for ring 22's is shown in Figures 12 and 13. The linear correlation of yarn elongation with fiber elongation increases from 0.33 to 0.61 for ring spun 22’s. Other counts show similar increases and are summarized in Table IV.

Stepwise regression was then used to model yarn CSP using USDA HVI test results (micronaire, length, UI, RD and b) plus strength and elongation measurements from both the USDA data and the Zellweger test. The results are summarized in Table V. Using either standard HVI or Stelometer strength and elongation measurements, typical correlation values are obtained. Substituting the new HVI strength measurement significantly improves all models. If we also substitute the new HVI elongation measurement, the models are again significantly improved.

Conclusions

The test by USDA using candidate calibration bales gives an average CV% for the short fiber measurement of 6.0% to 7.3% depending on the number of HVIs involved in the test. The increase in CV% is attributed to setup differences between HVIs. For a tolerance of 1%, the sustainment is 79.1% for repeat tests on different HVIs. Estimates from the standard deviations due to improvement in the setup procedures indicate that this will provide a negligible improvement in the sustainment. The conclusion is that the differences in the short fiber reading is much more dependent on the selection of the cotton sample than on the setup of the HVI.

The use of the index card technique provides an accurate measurement of the deflection in the breaker system of an HVI. A modified analysis of this corrected stress-strain curve then produces a measurement for elongation that is more precise and has a standard deviation that is approximately one forth of the standard measurements on the HVI. Comparisons of elongation measurements on the HVI using the new deflection calibration and elongation algorithm with bundle stress-strain curves generated from Mantis single fiber data showed similar levels of elongation, which are approximately 5% higher than traditional stelometer values. A possible reason for this level difference may be pretensioning in the Stelometer clamps.

The USDA crop samples from 1990 to 1994 were tested using the new algorithms. This data shows that the new elongation measurement is a much better predictor of yarn properties.

References

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Table I: USDA Short Fiber Tests on Candidate Calibration Bales.

B	N	L	S	U	S	St	S	E	S	S	S
2	6	1.	0.	8	0.	3	0	7.	1.	4	0
2	4	1.	0.	8	0.	3	1	7.	1.	4	0
2	9	1.	0.	8	0.	3	0	7.	1.	5	0
2	5	0.	0.	7	0.	2	0	7.	1.	1	0
2	1	1.	0.	8	0.	3	0	7.	1.	4	0
2	5	1.	0.	8	0.	3	0	8.	1.	4	0
2	5	1.	0.	8	0.	2	0	7.	1.	6	0
2	5	0.	0.	8	0.	2	0	7.	1.	1	0
2	4	0.	0.	8	0.	2	0	7.	1.	1	0
2	5	0.	0.	7	0.	2	0	7.	1.	1	0
2	5	0.	0.	8	0.	2	0	7.	1.	9	1
2	5	0.	0.	7	0.	2	0	6.	1.	1	0
2	5	0.	0.	8	0.	2	0	7.	1.	1	0
2	4	0.	0.	7	0.	2	1	7.	1.	1	0
2	5	0.	0.	7	0.	2	0	8.	1.	1	0
2	4	0.	0.	7	0.	2	0	8.	1.	1	0
2	5	0.	0.	7	0.	2	1	8.	1.	1	0
2	1	0.	0.	7	0.	2	0	7.	1.	9	0
2	5	0.	0.	7	0.	2	1	8.	1.	1	0
2	1	0.	0.	7	0.	2	1	8.	1.	1	0
2	4	1.	0.	8	0.	3	0	7.	2.	4	0
2	3	1.	0.	8	0.	3	1	7.	1.	4	0
2	4	1.	0.	8	0.	3	0	7.	2.	4	0
2	5	1.	0.	8	0.	3	0	7.	2.	4	0
2	3	1.	0.	8	0.	3	0	7.	1.	4	0
2	4	1.	0.	8	0.	3	0	7.	2.	4	0
2	4	1.	0.	8	0.	3	1	7.	1.	5	0
2	4	1.	0.	8	0.	3	1	7.	1.	4	0
2	5	1.	0.	8	0.	3	0	7.	2.	4	0
2	4	1.	0.	8	0.	3	0	7.	1.	4	0
2	4	1.	0.	8	0.	3	1	7.	2.	4	0
2	4	1.	0.	8	0.	3	0	7.	2.	4	0
2	4	1.	0.	8	0.	3	0	7.	2.	4	0
2	4	1.	0.	8	0.	3	1	7.	2.	4	0
2	4	1.	0.	8	0.	3	0	7.	2.	4	0
2	4	1.	0.	8	0.	3	0	7.	2.	4	0
2	4	1.	0.	8	0.	3	0	7.	2.	4	0
2	4	1.	0.	8	0.	3	0	7.	2.	4	0
2	6	1.	0.	8	0.	3	0	7.	2.	4	0
2	6	1.	0.	8	0.	3	0	7.	1.	4	0
2	5	1.	0.	7	0.	2	0	8.	1.	9	0
2	4	1.	0.	8	0.	2	1	7.	1.	8	0
2	6	1.	0.	8	0.	3	0	7.	1.	4	0
2	6	1.	0.	8	0.	3	0	7.	1.	4	0
2	6	1.	0.	8	0.	3	0	7.	1.	4	0
2	6	1.	0.	8	0.	3	0	7.	1.	4	0
2	6	1.	0.	8	0.	3	0	7.	1.	5	0
2	6	1.	0.	8	0.	3	0	7.	1.	4	0
2	5	1.	0.	8	0.	3	0	7.	1.	4	0
2	6	1.	0.	8	0.	3	0	7.	1.	4	0
2	6	1.	0.	8	0.	3	0	7.	1.	5	1
2	5	1.	0.	7	0.	2	0	7.	1.	9	0
2	5	1.	0.	7	0.	2	0	7.	1.	9	0
2	5	1.	0.	8	0.	2	0	7.	1.	8	0
3	6	1.	0.	8	0.	2	0	7.	1.	6	0
3	6	1.	0.	8	0.	2	0	7.	1.	6	0
3	6	1.	0.	8	0.	2	0	7.	1.	6	0
3	6	1.	0.	8	0.	2	0	7.	1.	6	0
3	6	1.	0.	8	0.	2	0	7.	1.	6	0
3	6	1.	0.	8	0.	2	0	7.	1.	6	0
3	6	1.	0.	8	0.	2	0	7.	1.	6	0
A	3	1.	0.	8	0.	2	0	7.	1.	6	0

Table II: Averages and Shift Values for USDA Checklots.

HVI Line	Average SFI	Difference
716	6.27 %	-0.52 %
717	6.69 %	-0.10 %
718	6.82 %	0.03 %
741	7.13 %	0.34 %
742	6.73 %	-0.06 %
743	6.64 %	-0.15 %
744	7.29 %	0.50 %
745	7.28 %	0.49 %
787	6.65 %	-0.14 %
788	6.45 %	-0.34 %
Avg	6.79 %	

Table III: Sustainment for USDA Checklots.

Tolerance	0.7 %	1.0 %	1.2 %
Sustainment	63.4 %	79.1 %	86.0 %
Est. Sustainment	58.8 %	75.5 %	83.7 %
Est. Shifted Sustainment	61.2 %	78.3 %	86.1 %

Table IV: Simple Correlation of Yarn Elongation with Fiber Elongation Measured by Stelometer and the HVI using the New Algorithm - 1990 to 1994 USDA Crop Samples.

	Open End			Ring		
Count	10's	22's	30's	22's	36's	50's
Stelometer	0.45	0.59	0.41	0.33	0.30	0.49
HVI	0.63	0.68	0.57	0.61	0.58	0.66

Table V: Multiple Correlation of Standard HVI Measurements (Micronaire, Length, UI, Rd, b) plus either Stelometer, Standard HVI or New HVI Elongation and Strength Values with Yarn CSP - 1990 to 1994 USDA Crop Samples.

	Open End			Ring		
Count	10's	22's	30's	22's	36's	50's
Stelometer El	0.786	0.785	0.779	0.832	0.83	0.848
Stelometer Str						
Std HVI El	0.831	0.794	0.768	0.830	0.821	0.802
Std HVI Str						
Stelometer El	0.794	0.798	0.766	0.840	0.836	0.821
Std HVI Str						
Stelometer El	0.850	0.863	0.843	0.875	0.886	0.879
New HVI Str						
New HVI El	0.882	0.889	0.871	0.903	0.911	0.903

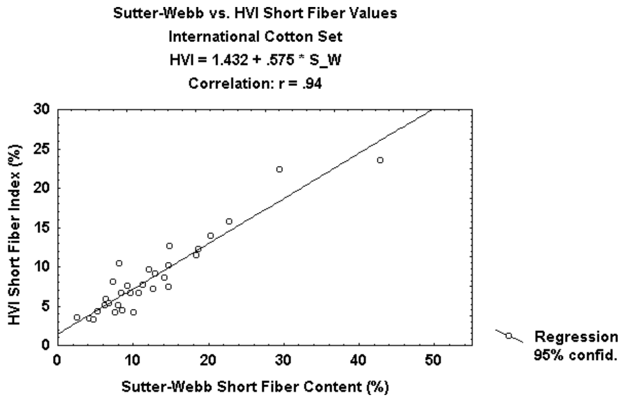

Figure 1: Suter-Webb Short Fiber Content vs. HVI Short Fiber Index for International Cotton Set.

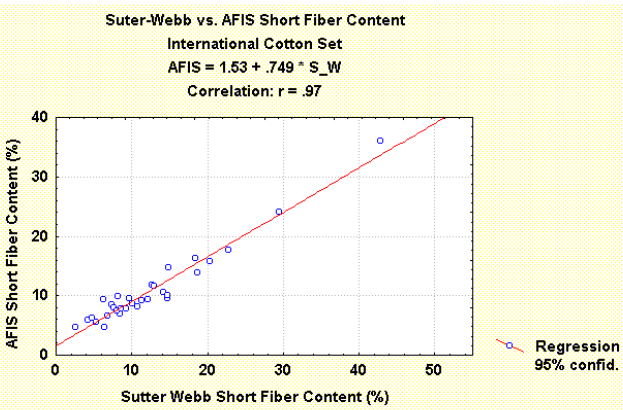

Figure 2: Sutter-Webb Short Fiber Content vs. AFIS Short Fiber Content for International Cotton Set.

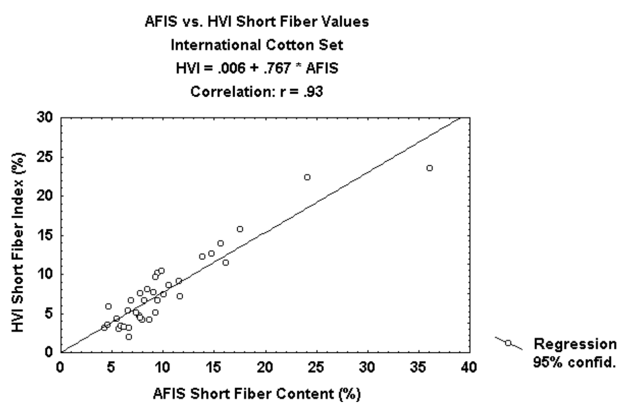

Figure 3: AFIS Short Fiber Content vs. HVI Short Fiber Index for International Cotton Set.

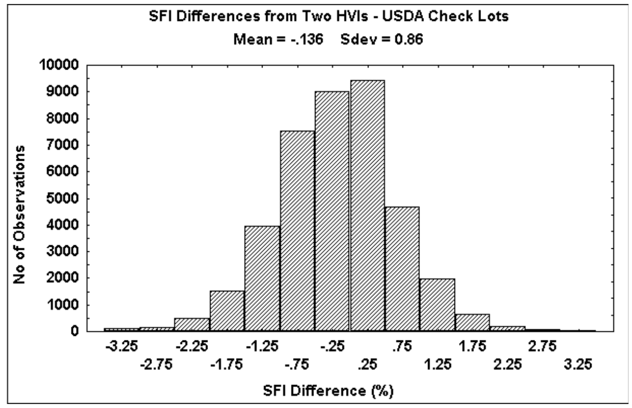

Figure 4: Distribution of SFI Differences from Two HVIs.

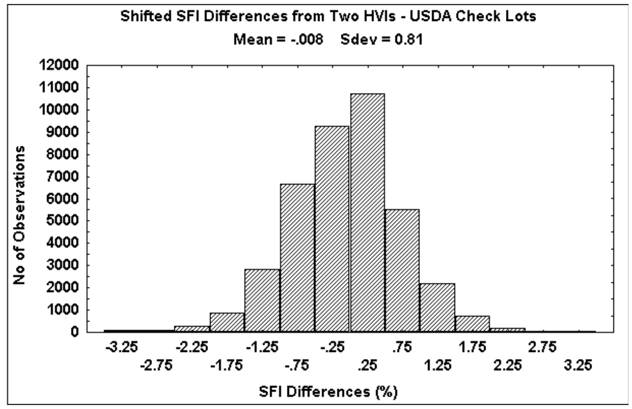

Figure 5: Distribution of Shifted SFI Differences from Two HVIs.

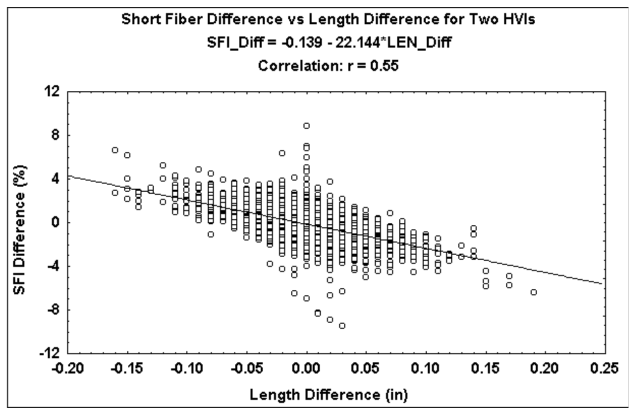

Figure 6: SFI Difference vs. Length Difference for USDA Checklot Samples on Two HVIs.

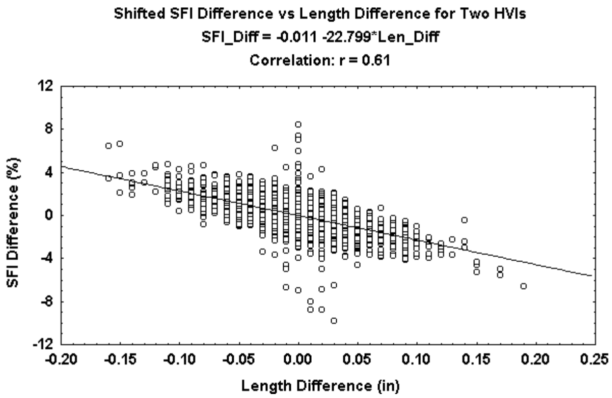

Figure 7: Shifted SFI Differences vs Length Differences for USDA Checklot Samples on Two HVIs.

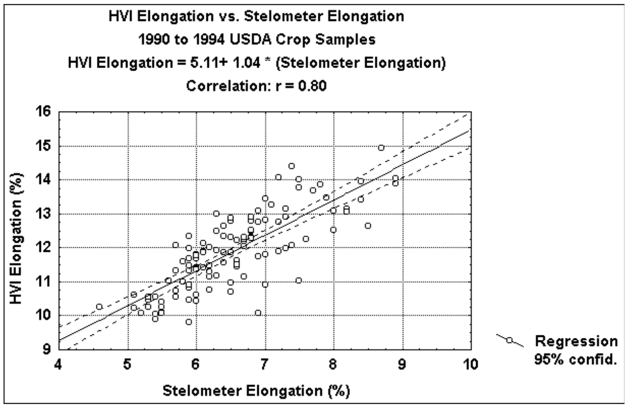

Figure 10: Stelometer Elongation vs. New HVI Elongation for 1990 to 1994 USDA Crop Samples.

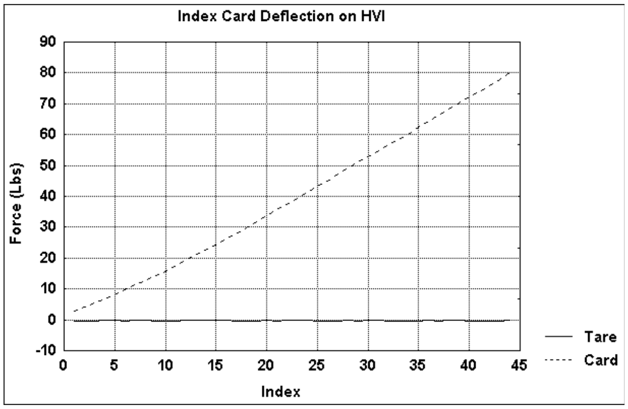

Figure 8: Deflection of an HVI Breaker System as a function of Force.

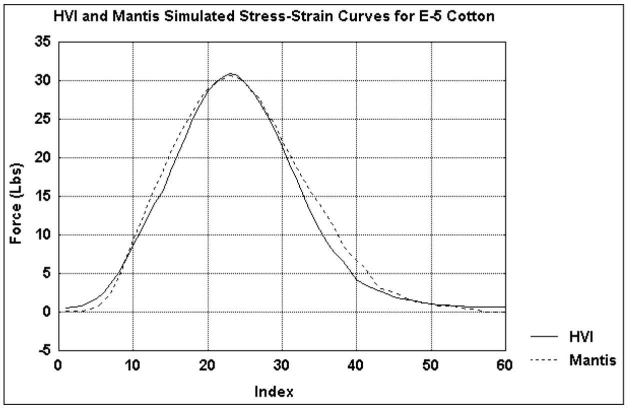

Figure 11: Stress-Strain Curves for HVI and Mantis Stimulated Bundle for E-5 Cotton.

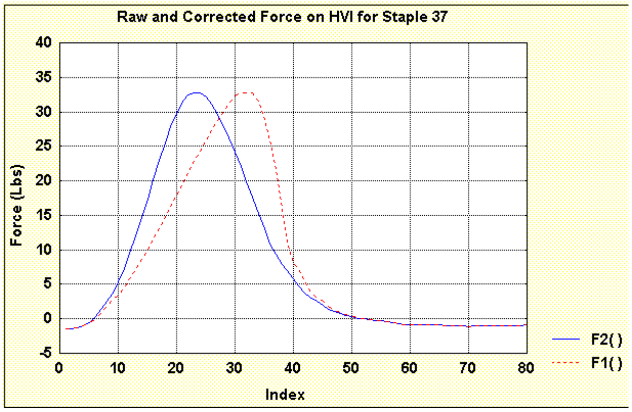

Figure 9: Raw and Corrected Stress-Strain Curve for Staple 37.

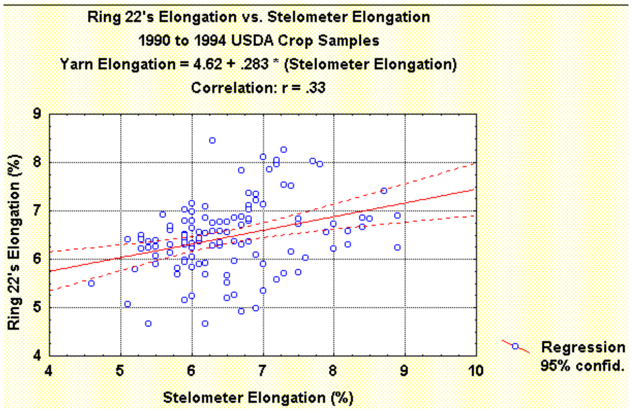

Figure 12: Ring 22's Elongation vs Stelometer Elongation for 1990 to 1994 USDA Crop Samples.

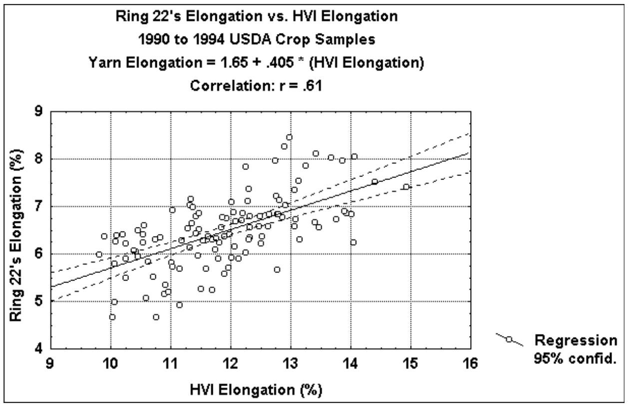

Figure 13: Ring 22’s Elongation vs HVI Elongation for 1990 to 1994 USDA Crop Samples.