BUNDLE ELONGATION MEASUREMENTS FOR INTERNATIONAL COTTON USING PREMIER HVI SYSTEMS

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Abstract

The elongation of cotton is measured as the percent of fiber stretching prior to reaching the maximum force during a bundle tenacity measurement. For HVI testing, the fiber specimen gage length is 1/8 inch and observed elongation readings are in the range of 5 to 15 percent. Therefore, accurate measurements require a rigid test fixture and extremely precise position sensing. In this report we describe some hardware design modifications and position sensing methods used to measure bundle elongation. HVI strength and elongation measurements were made on a series of cotton samples and compared with Stelometer results using 1/8 gage Presley clamps. Methods to calibrate elongation measurements with cotton and adjust observed results for fiber crimp, slippage and hardware deflections are discussed.

Introduction

Elongation is an important quality property of cotton. Cotton breeders need an accurate measurement of to evaluate their breeding program. Mill operators need to measure elongation so they can select cottons that will hold up in spinning and weaving and meet performance specifications of their products. Merchants should measure elongation so they can channel each cotton bale to its best use. Fiber quality measurements in marketing also provides a mechanism for the communication of value between the producers and consumers.

Elongation of has been investigated by numerous researchers. Hertel, et. al. [2] suggested that the true cotton elongation for fibers in bundles should be measured by subtracting measurements made at zero gage from those at 1/8 gage. However, he reported that reproducibility of this measurement was not good. Worley, et. al. [4] suggested that elongation measurements should be adjusted to account for the true gage length of the specimen being tested. By surveying five cottons, they found the true gage length was approximately 12% longer than the nominal gage length. However, the adjustment length was significantly different for different cottons. These complex modifications to the observed displacement measurement have never been adopted. However, when using the Stelometer method, observed values are reduced by 0.8 to correct for jaw slippage and gage length effects. Thit reduction causes reported values to be less than one would determine from an accurate analysis of the stress-strain trace.

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During bundle testing for cotton fiber strength, two interacting phenomena occur. Each can significantly alter the shape of the load-elongation trace. These phenomena are: 1. The removal of residual slack (i.e., crimp) as the bundle tension is applied and 2. The combined tensile force and breakage of fibers that have reached their maximum extensibility. Excess slack in some fibers will cause delayed or unequal loading and it reduces the maximum bundle force. Crimp can be observed from as a non linear rise during the initial portion of the stress strain signal (See Figure 1). Ideally, we would like to position all fibers with equal straightness to produce a linear rise and a measurement which accurately indicates fiber properties (strength and elongation) and not its method of preparation. Since equal fiber straightness is not currently practical, crimp and slippage must be minimized and controlled to produce elongation measurements with precision and accuracy.

Experimental Materials and Methods

Bale samples (i.e., as ginned) were used in these experiments to insure that the precision and accuracy of elongation measurements were consistent with those expected from production HVI systems. The experimental cotton samples included a wide range of fiber properties (Table 1). These cottons were grown commercially across the US cotton belt during the 1992 season. They were selected for use in cotton variety evaluations [3]. Testing was performed in a controlled laboratory environment.

High Speed Instrument

Evaluations of the HVI elongation measurement was made with the Premier system (Model 9000). It provided elongation measurements during tenacity testing of fibers (prepared in tapered bundles) and tested using 1/8 gage (3.175 mm) test specimens. The strength measurements were made at an extension rate similar to other HVI systems (approximately 13 cm/min). Other features which may influence elongation measurement were:

1. Displacement sensing: The HVI system included a precision Linear Voltage Displacement Transducer (LVDT) to record breaker jaw movement during strength testing. This device converts a DC voltage into an AC signal to sense the position of a magnetic core attached to the HVI jaws. The resulting AC signal is converted back to DC for output (See Figure 2). Movement at the breaker jaws was also calculated with mechanical design information and the pulse rate of the force generating stepping motor.

2. Analysis: Elongation from the Premier HVI system was based on the tangent modulus method. We measured and recorded force and displacement from the closing position to 40 % of the gage length position. Bundles were prepared

with an automated brushing system which can produce different levels of fiber crimp and may altered the initial shape of the stress-strain curve. Therefore, we chose to start the elongation measurement at the point where a line tangent to the steepest rising portion of the stress-strain curve intersects the baseline. This tangent line represents the bundle modulus of elasticity.

3. Jaw Surface: Strength testing jaws in the HVI system are lined with a durable plastic which was designed to extend above fixed jaw surface. The plastic is replaced annually or when a noticeable slippage occurs.

4. Stiffness: The strength testing hardware was sufficiently rugged such that the tensile force caused a maximum hardware deflection of 3.3 % of nominal gauge (i.e., 0.11 mm) when testing a 30 gf/tex sample of Pima cotton. Hardware deflection was estimated by comparing the displacement reading at maximum force loading with the jaw displacement at the same time for no loading (See Figure 3).

Results and Discussion

Correlation coefficients for average HVI values compared with published Stelometer data using 23 leading variety cottons showed a regression coefficient (R^2) of 0.80 and a Standard Error (SE) of 0.45% elongation (See Figure 4). Accuracy of this data was quite good considering that stated critical difference between two means for a six specimen Stelometer test was 1.85% [1].

Conclusions

Elongation based on initial modulus and displacement signals recorded with a precision LVDT sensor can be used to improve the agreement of elongation with other instruments.

Literature Cited

Am. Soc. for Testing Materials, Committee D-13 on Textile Materials, ASTM Designation 1445-75.

Hertel, K.L. and Craven, D. J., Cotton Fiber Bundle Elongation and Tenacity as Related to Some Fiber and Yarn Properties, Textile Res. J. 26(6), 479-484 (1956).

USDA, Fiber and Processing Test Survey of Leading Cotton Varieties, Crop of 1992 Agricultural Marketing Service, Cotton Division (August 1993)

Worley, S. Jr., Krowicki, R. S. and Henry, Z. A., Effects of Variety and Location on Stress-Strain Components of Cotton Fiber Bundles, Part I: True Gage Length, Tenacity and Elongation at One-Eighth-Inch (0.3175 cm) Nominal Gage Length, Textile Res. J. 36 (10) 893-899 (1966).

Table 1. Fiber properties of the cotton samples tested from the 1992 Leading Variety Study[4].

		Stelometer			PremierHVI		
Lot No.	T1 (gf/tex)	E1 (%)	UHM (in.)	UR (ratio	Strength (gf/tex	Elongation. (%)	Mic units
1	23.3	7.0	1.11	81.49	27.27	7.90	3.8
2	20.8	7.8	1.07	81.81	26.69	7.92	4.3
3	23.6	6.0	1.02	80.15	25.92	6.70	4.3
5	25.6	6.0	1.08	81.75	30.75	6.19	4.35
6	25.4	6.0	1.09	81.22	28.80	6.09	4.3
7	24.7	6.2	1.03	78.78	26.18	6.13	3.9
8	27.4	5.5	1.06	81.67	29.10	5.30	4.3
9	23.0	7.1	1.12	81.39	29.21	7.33	3.3
10	23.0	7.0	1.09	81.56	26.12	7.39	3.9
11	23.9	7.0	1.11	82.04	28.47	7.02	4.2
12	23.7	7.2	1.16	83.46	28.40	7.18	4.4
13	23.9	6.8	1.06	79.85	27.83	6.01	3.6
14	23.3	6.7	1.11	81.67	27.63	7.12	4.8
15	25.7	7.2	1.03	81.92	28.84	7.83	3.6
16	26.3	7.7	1.06	82.72	30.88	8.17	3.9
17	26.8	6.9	1.08	81.00	27.29	6.64	2.8
18	26.1	7.3	1.07	80.53	28.37	6.41	3.2
19	28.4	5.1	1.15	83.47	32.31	5.22	4.1
20	28.5	5.7	1.15	83.98	31.63	5.39	4.4
21	27.3	5.9	1.16	84.57	31.78	5.60	4.5
22	27.5	5.7	1.10	82.77	29.33	5.55	4.2
23	29.1	5.4	1.15	84.23	33.59	5.48	4.1
24	26.6	5.5	1.12	82.06	30.84	4.82	4.2

T1 and E1 are 1/8 gage strength and elongation by the Stelometer method. UHM and UR are upper half mean and uniformity ratio by the HVI method.

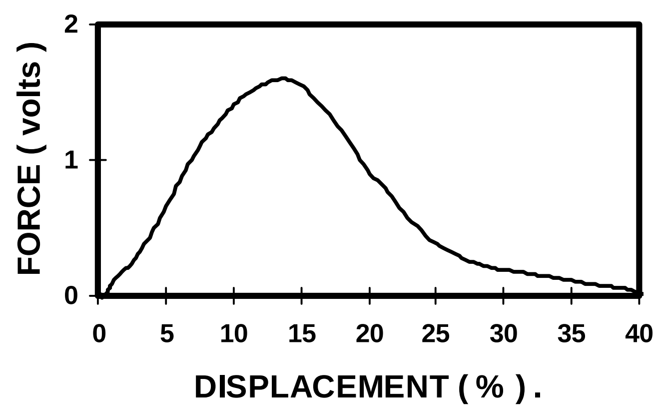

Figure 1. Force- Displacement Trace Showing 2 to 3 % Initial Crimp.

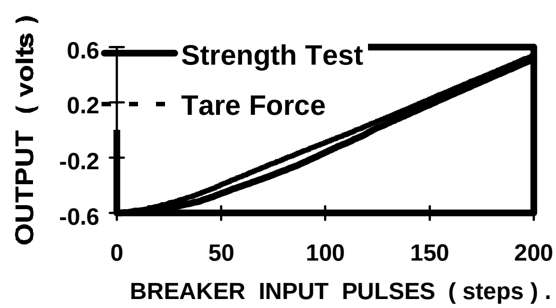

Figure 2. Displacement Voltage Signals.

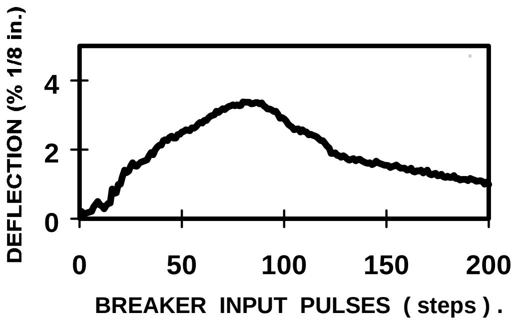

Figure 3. Hardware Deflection During Cotton Testing. (Maximum = 3.3 % of 1/8 in. Gauge).

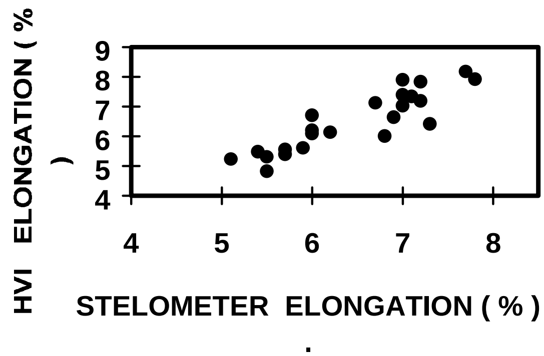

Figure 4. Comparison of Elongation Results.(R squared = 0.80 , S. E. = 0.45 %).