NEW DEVELOPMENTS IN HVI MEASUREMENTS

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Abstract

The new developments in HVI SPECTRUM measurements are introduced and discussed. The emphasis is given on improved color and trash measurement, the new automated sampling technique, and the new maturity index and moisture measurement. The maturity index is explained and compared to the AFIS maturity ratio. The new moisture measurement is compared to a standard hand-held moisture probe.

Sample moisture and its variance is discussed and related to the conditioning of samples and the required air conditioning equipment in the laboratory. A mill trial shows the result of the application of the moisture correction algorithm introduced for the first time with the HVI SPECTRUM.

Introduction

Zellweger Uster introduced a new HVI - the SPECTRUM - at the ITMA exhibition in Paris in June 1999. The HVI is available with one cabinet for length and strength measurement as a SPECTRUM I or with two length / strength cabinets as a SPECTRUM II as shown in Figure 2 for greater sample throughput. A 233Mhz Pentium with a 10-gigabyte hard drive, 32 Meg of memory and a CDROM drive powers the HVI. The operating system is Windows 98. The new operating software is icon based and includes much simplified operation and calibration procedures. Also included in the new SPECTRUM are the USTER® QualiProfile and Bale Management software programs.

This report will discuss the following new developments of the SPECTRUM as listed in Figure 3:

- Improved color and trash measurement
- Completely automated sampling
- Accurate and precise maturity index
- Automatic moisture measurement

Figure 4 shows the top view of the HVI SPECTRUM. The color and trash window with the moisture hand is located on the left, the length/ strength sampling station in the middle and the Micronaire measurement on the right side of the testing cabinet.

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Color / Trash

Although similar in appearance to the color measurement head in prior instruments, the new HVI SPECTRUM incorporates some major improvements as listed in figure 5. It utilizes a patented xenon flash tube technology initially developed for the Gin Process Control systems. The major advantages are in the long life of the flash tubes as compared to the incandescent light bulbs and the generation of less heat during operation. The older color heads required a minimum of one hour to reach a stable operating temperature while the xenon tube requires only a few flashes. A sensor circuit is used to trigger the color/trash readings at a constant light intensity. In addition, a new four-quadrant calibration routine has been added for color and a new, more stable calibration routine for trash. With these new calibration routines, there is seldom any need to recalibrate the unit following the initial adjustments.

Automated Sampling

The sample plate is shown in the center of Figure 4. This perforated plate is the same design as the traditional 192 Fibrosampler or a HVI 900 Automatic. The hole size and spacing is identical to previous fiber samplers. Figure 6 shows the comb passing over the sampling plate as it collects fibers. A pressure hand moves down and holds the sample with consistent pressure against the sample plate while the comb is collecting the fibers.

Figure 7 shows the different stages of the sampling process in a side view:

A stepper motor connected to a ball nut drive assembly moves the comb.

This comb assembly is connected to three air cylinders, which give four distinct vertical levels. The comb is identical in needle size, length and spacing to previous HVI sample combs. However, the clamping screw is connected to a rotary air cylinder. When the comb completes its travel collecting fibers, the clamping screw rotates as the comb drops to the second level. This clamps the fibers in place. The comb then advances into the card as the card rotates. This design produces a ramped carding action as in the previous Fibrosampler. The length of the carding section is identical to the carding section of a Fibrosampler or a HVI 900 Automatic sampler. The card wire is the same as that used on the HVI 900 Automatic.

The comb then drops to level three and is brushed by the same brush as is used in all previous HVIs. The only difference is that an air cylinder controls the brush pressure allowing for consistent pressure for all instruments. The comb then drops to level four and advances toward the length / strength measuring unit.

After taking the length/ strength measurement, the comb returns to level three, rotates to release the fiber beard and advances into the brush, which is rotating in the opposite direction to doff the beard. The comb then backs out and returns to level one ready for the next sample while the brush lifts into the card and cleans the card. Excess fibers are released into a vacuum opening located behind the brush.

Figure 8 shows all components in a photograph from the rear side of the instrument.

The length / strength module ("breaker") shown in figure 9 is a complete new mechanical design. However, the sections of the jaw that clamp the fibers retain all critical dimensions from the HVI 900's. The optical system is also the same as in previous HVI designs. The new breaker is much smaller and lighter than the large tower used in the old HVI instruments. Clearly visible are the air cylinders used for the clamping mechanisms within the breaker.

Maturity

The maturity index is a calculation based on an algorithm that was developed using a wide range of international cotton samples. A summary of properties for this original sample set is shown in table 1. The range of values, cotton types and origins are unique and cover cotton varieties grown throughout the world. The samples were measured on an AFIS for maturity ratio and on a HVI for micronaire, length, uniformity and strength values. The results range from:

Micronaire	2.7 to 8.5
Maturity Ratio	0.69 to 1.05
Length	0.67" to 1.50"
Uniformity	73.5% to 88.4%
Strength	20.3 to 43.7 g/tex

The algorithm contains the HVI measurements of micronaire, strength and elongation (figure 10). The results are obtained simultaneously with the length / strength and micronaire measurements. Figure 11 shows results of the maturity measurement on the AFIS compared to the maturity index on the HVI SPECTRUM. The correlation of 0.93 indicates that the SPECTRUM provides an excellent method for detecting maturity.

Moisture

The sample hand above the Color/Trash head is used to provide a constant pressure on the cotton sample. Incorporated into this hand is a resistance moisture sensor technology licensed from USDA (figure 12).The consistent pressure of the hand ensures repeatable moisture results. There is no customer calibration of the moisture probe. Figure 13 shows the SPECTRUM moisture readings on a series of samples conditioned at different relative humidity levels as compared to a traditional hand-held moisture probe. The SPECTRUM moisture measurement compares excellently to the handheld device with a correlation factor of 0.92. In addition, experience has shown that the new SPECTRUM moisture probe is much less operator dependent.

The influence of moisture content on cotton strength results is shown in figure 14. The correlation factor of 0.94 indicates that strength results depend highly on the moisture content of the cotton sample. In fact, we could see a swing in strength results from 32.2 g/tex to 34.3 g/tex when the laboratory is within tolerance.

ISO 139 standard ambient conditions for sample testing require 68˚F ± 4˚F (20˚C ± 2˚C) for temperature and 65% ± 2 % for relative humidity). To attain moisture equilibrium, a conditioning time of at least 24 hours is required, 48 hours is preferred (figure 15).

In addition to these standard ambient conditions, for a laboratory to produce reliable results, the following practices and operations should be in place:

- The conditioning equipment must function properly.
- Vents should be adjusted to provide as uniform air distribution as possible because large rooms may show variations in relative humidity of greater than 5% throughout the room.
- Double air lock doors or a similar mechanism should be used to avoid transients. Excessive traffic will cause large localized swings in moisture in the air.
- Samples should always be conditioned from the dry side since the adsorption process from the wet side is much slower and will most likely not result at the same moisture level compared to conditioning from the dry side.
- Calibration cottons should be stored in the same area as the test samples to allow comparable conditioning. Never store cotton samples in plastic bags!

In reality, most laboratories do neither follow these standard practices nor do they have the required air conditioning equipment in operation.

All cottons do not equilibrate to the same moisture when exposed to the same atmosphere. This is shown graphically in figure 16 and figure 17 where the distribution of sample moisture is given when the sample set is conditioned at 55 % relative humidity and 75 % relative humidity respectively.

Ideally, we would measure the sample moisture and correct fiber length and strength to the moisture content at which that cotton would equilibrate to at standard conditions. However, we have found no method of estimating this moisture level from fiber properties. Instead we have taken the approach of correcting the values to 8.0 % moisture. This seems to be an appropriate mean moisture value at standard conditions as indicated by the average of the last two figures.

In figure 18 we show the normalized strength error calculated for the same set of cottons. It clearly shows the bimodal distribution of the samples conditioned and tested at 55 % relative humidity (data to the left side) and at 75 % relative humidity (data to the right side). The result of applying the moisture correction algorithm is shown in figure 19.

The standard deviation of 0.05 means that 67 % of the strength results have less than +/- 5% error when tested at non-standard conditioning levels. This is approximately the same as that obtained by a laboratory whose conditioning meets the standard requirements mentioned above. Thus, the moisture correction algorithm can considerably reduce the measurement error due to differences in cotton moisture.

Mill Trial

In order to see the effect of the conditioning process on the measurement results and to prove the validity of the moisture correction algorithm the following mill trial was set up (figure 20):

Cotton samples were taken from two consecutive laydowns A + B, representing three different growth areas. Laydown A remained unconditioned in the beginning. Laydown B was conditioned 24 hours to standard ambient conditions. Both were tested in this stage on the HVI SPECTRUM. Then, the moisture correction algorithm was applied and both laydowns were retested on the HVI at the same conditions. Then, laydown A was conditioned to 16 hours and laydown B to 30 hours and tested one more time on the HVI SPECTRUM without the moisture correction algorithm applied.

The results are displayed in figure 21 to 25 and summarized in figure 26 as follows:

- The conditioning process does not affect Micronaire results
- Uniformity and short fiber index results can be somewhat affected by the conditioning process.
- The moisture correction algorithm does positively affect length and strength results.

These results confirm that with an accurate moisture measurement, changes in sample conditioning that affects cotton length and strength data can be reduced considerably. This is a great advantage for HVI users that are unable to afford expensive laboratory conditioning as well as reducing the 24-hour sample conditioning time to a practical level. In addition, we have learned with further data analysis that the cotton moisture content should be above 6% in order to give repeatable measurement results.

Table 1. Maturity Sample Set

Cotton	Mic	Length	Unif	Str	AFIS MR
M1 (H-3)	5.87	0.992	81.2	25.93	0.94
M2 (G-19)	2.83	0.989	79.1	23.61	0.69
M3 (B-26)	4.42	0.979	80.4	24.31	0.78
M4 (C-37)	3.46	1.168	83.0	30.09	0.79
M5 (D-7)	3.97	1.368	85.4	37.84	0.87
M6 (G-21)	2.72	0.960	78.5	25.71	0.76
M7 (D-5)	3.82	1.365	84.9	43.45	0.92
M8 (Low Sugar)	4.63	1.085	81.9	29.68	0.90
M9 (High Sugar)	4.93	1.137	82.7	27.07	0.85
M10 (Low Mat)	2.68	1.005	79.2	23.09	0.72
M11 (High Mat)	4.70	1.074	80.2	29.12	0.91
M12 (India B)	7.89	0.706	73.5	20.46	0.97
M13 (India I)	3.54	1.338	84.7	29.18	0.85
M14 (India F)	3.05	0.859	70.4	25.36	0.81
M15 (India C)	5.04	0.958	80.5	25.87	0.94
M16 (India E)	3.47	1.014	81.6	24.62	0.84
M17 (India G)	3.31	1.502	88.4	38.88	0.86
M18 (India D)	3.56	1.133	82.6	28.35	0.89
M19 (India H)	4.23	1.080	83.1	28.72	0.90
M20 (India A)	7.69	0.688	74.1	20.31	0.95
M21 (Short/Weak)	3.89	0.970	78.9	22.85	0.81
M22 (GRT Long)	3.91	1.157	83.9	30.33	0.87
M23 (8x8 High Mic)	3.58	1.188	83.8	32.35	0.86
M24 (HVI Cal.)	5.04	1.110	81.4	28.60	0.92
M25 (44 Staple)	3.44	1.369	84.1	32.88	0.83
M26 (48 Staple)	4.38	1.339	84.5	38.57	0.91
M27 (Pakistan)	3.96	1.090	80.6	23.86	0.84
M28 (Garyl Hill)	8.47	0.743	75.2	23.05	1.05
M29 (Sudan)	3.85	1.099	82.7	27.15	0.85
M30 (Sudan)	3.93	1.119	84.3	28.18	0.91
M31 (Sudan)	4.12	1.064	82.5	25.69	0.87
M32 (NL21)	4.40	1.321	84.4	43.73	0.91
M33 (NL11)	3.86	1.136	80.7	27.61	0.81
M34 (A-21)	5.36	1.069	82.4	27.30	0.87
M35 (YTC 1)	2.60	1.010	80.7	25.23	0.69
M36 (YTC 2)	3.56	1.024	82.5	27.63	0.72
M37 (YTC 3)	4.08	1.119	83.9	28.88	0.80
M38 (YTC 4)	4.50	1.126	83.8	28.37	0.82
M39 (YTC 5)	4.97	1.038	81.8	28.92	0.86
M40 (YTC 6)	5.48	1.054	83.1	26.45	0.88
M41 (E-4)	3.20	1.324	84.2	35.57	0.81
M42 (A-18)	5.57	1.007	80.6	23.91	0.88
M43 (29380 Short)	4.02	0.963	78.5	23.72	0.84
M44 (28693 Long)	3.87	1.153	83.9	31.17	0.87
M45 (28632 Short)	4.46	0.952	78.9	23.49	0.86
M46 (29428 Long)	4.18	1.183	84.1	32.69	0.89

New Developments in HVI Measurements

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Figure 1. Title

USTER® *HVI SPECTRUM II*

Figure 2. USTER® HVI SPECTRUM

USTER® *HVI SPECTRUM*

NEW DEVELOPMENTS

- **Improved color and trash measurement**
- **Completely automated sampling**
- **Accurate and precise maturity index**
- **Automatic moisture measurement**

Figure 3. New Developments

USTER® *HVI SPECTRUM*

Color/ Trash/ Moisture, Fiber Sampling Station,

Micronaire

Figure 4. Color/ Trash/ Moisture, Fiber Sampling Station

USTER® *HVI SPECTRUM*

Improved color and trash measurement:

- **Patented xenon flash tube instead of incandescent light bulbs on previous HVIs**
- **Advantages:**
  - **+ Long life time of xenon flash tubes**
  - **+ Generates less heat**
- **Sensor circuit for constant light intensity**
- **New calibration routines for color and trash**

Figure 5. Improved color and trash measurement

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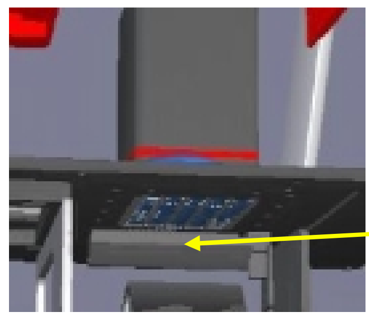
Completely automated sampling

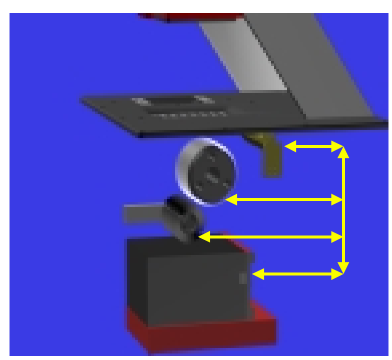


Comb sampling cotton

Figure 6. Comb sampling cotton

USTER® *HVI SPECTRUM*

Completely automated sampling



Side view:
1 - Sampling
2 - Carding
3 - Brushing
4 - Measuring

Figure 7. Automated sampling – side view

USTER® *HVI SPECTRUM*

Completely automated sampling

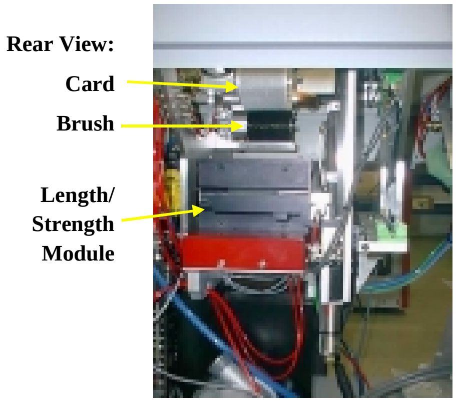


Figure 8. Automated sampling – rear view

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Length/ Strength Module ("Breaker")

Figure 9. SPECTRUM breaker assembly

USTER® *HVI SPECTRUM*

Accurate and precise maturity index

- **Algorithm based on a wide range of international cottons**
- **Algorithm contains HVI measurements of micronaire, strength and elongation**
- **Simultaneous measurement with length, strength and micronaire**
- **High correlation to AFIS maturity ratio results**

Figure 10. Accurate and precise maturity index

USTER® *HVI SPECTRUM*

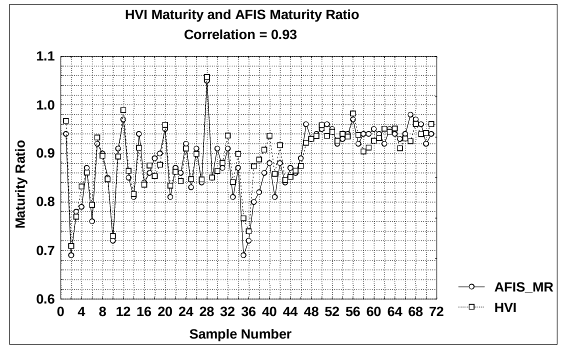

Figure 11. SPECTRUM Maturity Index vs. AFIS Maturity Ratio

USTER® *HVI SPECTRUM*

Automated moisture measurement

- **Patented resistance moisture sensor**
- **Direct measurement**
- **Sensor located underneath color/ trash hand**
- **Consistent pressure ensures repeatable moisture results**
- **No customer calibration required**

Figure 12. Automated moisture measurement

USTER® *HVI SPECTRUM*

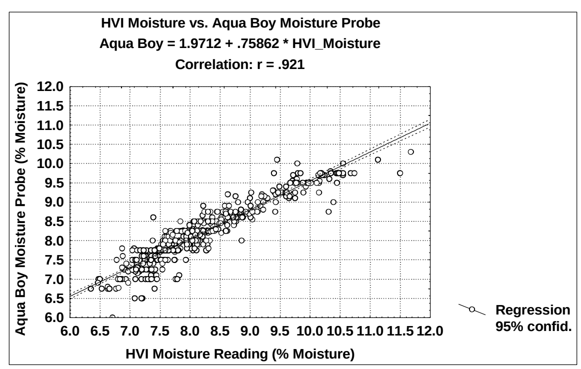

Figure 13. HVI moisture measurement vs. handheld moisture probe

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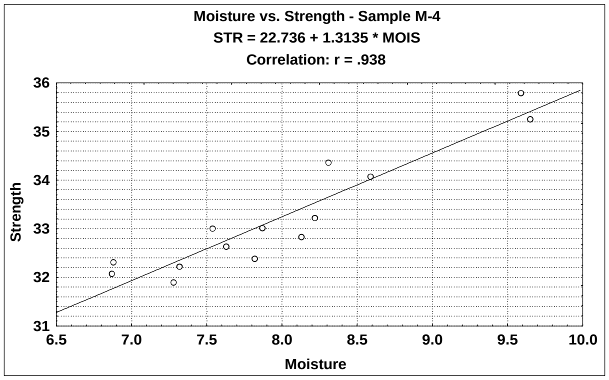

Figure 14. Influence of moisture content on strength results of one cotton sample

USTER® *HVI SPECTRUM*

Standard Atmospheric Conditions (ISO 39):

– **Temperature of 68 ± 4° F (20 ± 2° C)**
– **Relative Humidity of 65 ± 2 %**

**To attain moisture equilibrium,
a conditioning time of
at least 24 hours (ASTM) is required,
48 hours is preferred.**

Figure 15. Standard atmospheric conditions

USTER® *HVI SPECTRUM*

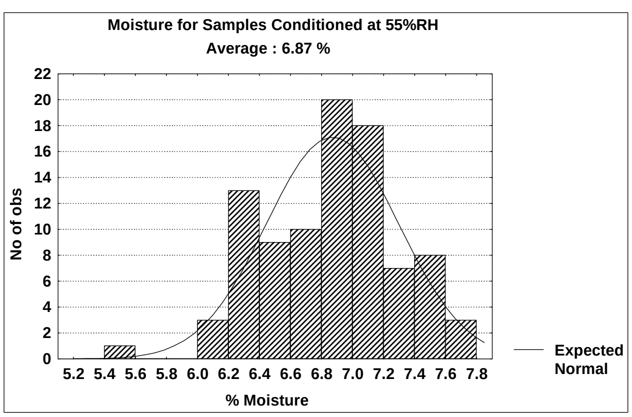

Figure 16. Moisture distribution for samples conditioned at 55% R.H.

USTER® *HVI SPECTRUM*

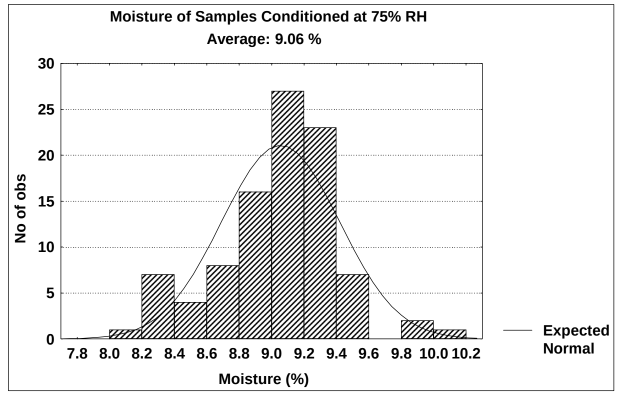

Figure 17. Moisture distribution for samples conditioned at 75% R.H.

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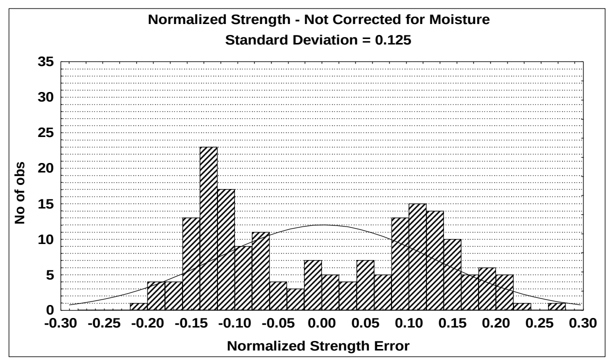

Figure 18. Normalized strength error for samples conditioned at 55% and 75% R.H.

USTER® *HVI SPECTRUM*

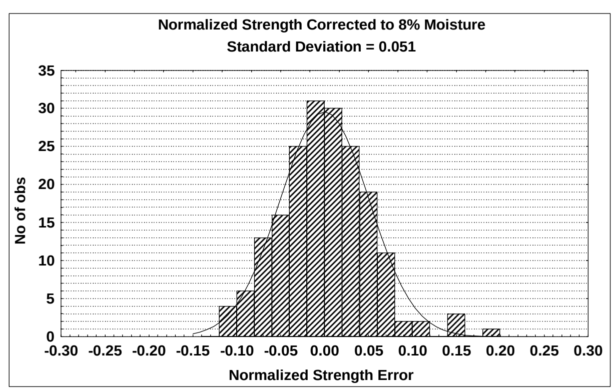

Figure 19. Normalized strength error for samples after correction to 8% moisture content

USTER® *HVI SPECTRUM*

- **Cotton samples taken from 2 laydowns (laydown A + B)**
- **Representing 3 different growth areas**

Trial Setup:

1. **Laydown A remained unconditioned**
   Laydown B was conditioned 24 hours
2. **Moisture Correction Algorithm was applied to both laydowns**
3. **Laydown A was conditioned 16 hours**
   Laydown B was conditioned 30 hours

Figure 20. Mill trial of moisture correction algorithm – trial setup

USTER® *HVI SPECTRUM*

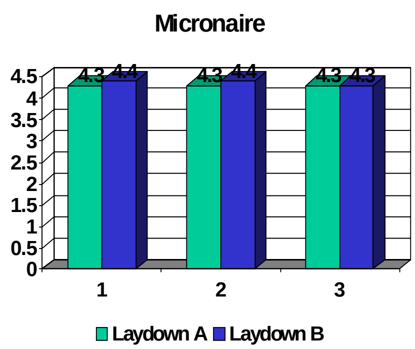

Figure 21. Mill trial of moisture correction algorithm – Micronaire

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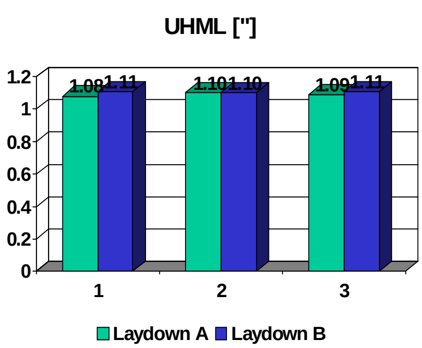

Figure 22. Mill trial of moisture correction algorithm – Length

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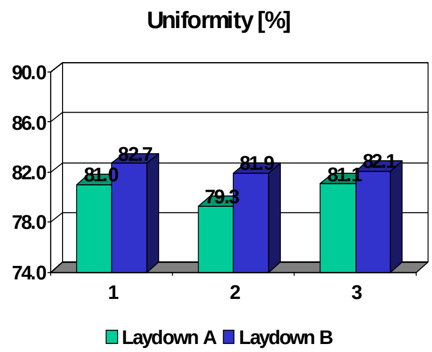

Figure 23. Mill trial of moisture correction algorithm – Uniformity

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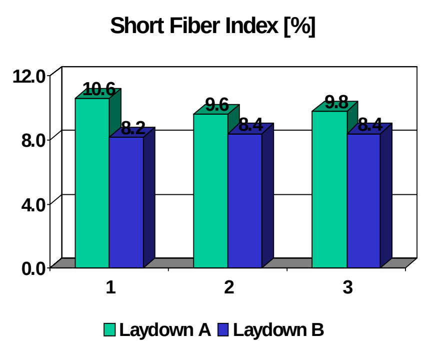

Figure 24. Mill trial of moisture correction algorithm – Short Fiber Index

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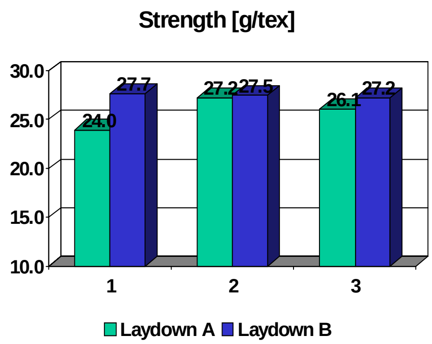

Figure 25. Mill trial of moisture correction algorithm – Strength

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Results:

- **Micronaire results are not affected by conditioning process**
- **Uniformity and short fiber index results can be somewhat affected by conditioning process**
- **Moisture correction algorithm positively affects length and strength results**

⇒ **Sample Conditioning time can be reduced to a practical mill level**

⇒ **Sample moisture should be above 6% to give repeatable measurement results**

Figure 26. Mill trial of moisture correction algorithm – Conclusion