UPGRADED ALMETER GIVES DETAILED MEASURES OF FIBER LENGTH PARAMETERS

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Abstract

Preliminary results are reported on a study to determine the feasibility of The Almeter (AL-101) is used together with the Fibroliner (FL-101) that prepares a small sample of fiber into an aligned array that is transferred to the AL-101 where it is sandwiched between two plastic foils and inserted between the plates of a condenser slot where it can be accurately scanned. The scan records the length of the fiber array in steps of 0.125 mm. The original Almeter that was based on forty-plus year-old technology has been upgraded with state-of-the-art electronics and revised software. Results are reported on a set of cotton length standards measured for mean length and short fiber content calculated based on both fiber weight and number. Comparisons are made with measurements on the same samples with AFIS Pro and Suter-Webb array analyses.

Introduction

The Suter-Webb Array (SWA) method (ASTM, 2007) has long been considered the preferred reference method for measuring cotton fiber length and length distribution. Prior to its closure in 2012, the Cotton Quality Research Station (CQRS), Clemson routinely characterized fiber length using this method. CQRS often considered the possibility/feasibility of replacing the array method with the Peyer Almeter AL-101 (ASTM, 2000) since the station owned an AL-101. This did not seem feasible since the instrument was fairly old and it was difficult to obtain parts or service since Peyer Company no longer exists. The issue was solved when it was learned that Prof. Urs Meyer, texma.org, was refurbishing Almeters and we arranged for him to redo Clemson's device with modern electronics and new software. Refurbishing was completed in 2011 and CQRS closed in 2012. The refurbished Almeter now resides at the Cotton Structure and Quality Research Unit in SRRC, New Orleans.

Materials and Methods

The Suter-Webb Array comb sorting apparatus consists of two banks of parallel combs that straighten and align the fibers presented to the combs. The test specimen is a bundle of fibers weighing 75 mg. The fibers are pulled in such a way as to be transferred from one bank of combs to the other in such a manner that one end of each fiber is aligned with the base comb. The process is again repeated so as to straighten the opposite ends of the fibers. The fibers are then withdrawn from the combs for the third time, now in separate length groups and are placed in decreasing order of lengths onto velvet-covered boards. Each length interval is collected at 0.125 in. and weighed starting at 0.125 in. through 2.375 in. From these weight-length data, the upper quartile length, mean length, and coefficient of length variation are calculated. Data for this study obtained at CQRS is based on measurements averaged from three different operators. Time for the test is approximately 50 minutes.

The Peyer Almeter system was originally developed for measuring the wool fiber length but has proven to be an easy and relatively rapid way to determine the length distribution of cotton fibers. The Peyer comprises two systems: a) one sorts and aligns a fiber bundle with the ends of the fiber bundle uniformly aligned on one end; and b) the other measures the length distribution of the fibers. The Fibroliner (FL-101) (Figure 1.) mechanically combs the cotton samples into a parallel bundle or end-aligned beard. The aligned fibers are placed between a pair of carrier films for length determination (Figure 2). The Almeter (AL-101) (Figure 3.) scans the beard using a sensitive capacitor that produces an output signal that is proportional to the cumulative distribution of the mass along the beard. The mass of fibers in the test specimen are scanned every 0.125-mm (0.005-in.). The output signal containing data on mass distribution is converted to number distribution considering that the linear density of the

fibers is assumed to be constant. The Almeter produces length measurements based on both fiber mass distribution and number distribution. Measurements are carried out by a single operator but are based on the average of five repetitions. Total time required for the test is approximately 30 minutes.

Figure 1. Fibroliner FL-101

Figure 2. End-aligned fiber beards

Figure 3. Peyer Almeter AL-101

The materials used in these studies were comprised of a set of eight reference cottons obtained from the USDA Agricultural Marketing Service (AMS) known as 8x8 Evaluation Cottons. These 8x8 cottons are a set of eight cottons which represent short to long cottons typical of the US cotton production. The 8x8 cottons are normally used for acceptance testing of High Volume Instruments and are selected based on their uniformity and repeatability of measurement.

Results and Discussion

The 8x8 cottons were initially characterized using the Suter-Webb Array method at the USDA-ARS Cotton Quality Research Station that was located in Clemson, SC. Data is based upon averaging the efforts of three technicians. Results in Table 1 are given for each of the eight cottons in thirty-second staple increments from 31 to 38. The three results columns contain length by weight measured in inches (L(w)), the coefficient of variation of this length (L(w) Table 1. Suter-Webb Results CV (%)), and the percent short fiber by weight (SFC(w) %). The mean length L(w) varies between 0.714 and 1.04 inches with an average od 0.9 inches. The coefficient of variation CV (%) of L(w) varies between 43.1% and 31% and has a tendency to decrease with the longer lengths. The average of the CV's is 33.59%. The fourth column lists the short fiber content SFC(w) % which varies from a low of 9.3% in the 38/32 group to a high of 28% in the 32/32 inch group. The short fiber content averaged over all the groups is 13.78%.

Table 1. Suter-Webb Array Data

8x8 ID	L(w) (in)	L(w) CV%	SFC(w) (%)
31	0.784	35.4	17.0
32	0.714	43.1	28.0
33	0.896	30.3	10.1
34	0.852	34.6	15.6
35	0.930	31.7	10.5
36	0.988	31.5	10.1
37	1.005	31.1	9.3
38	1.040	31.0	9.6
AVG	**0.9**	**33.59**	**13.78**

The 8x8 cottons were characterized using the AFISPro instrument at the USDA-ARS-SRRC (Southern Regional Research Center) Cotton Structure and Quality (CSQ) Research Unit was located in New Orleans. Data is based upon averaging the results of five runs of five thousand fibers, each. Results shown in Table 2 are again given for each of the eight cottons in thirty-second staple increments from 31 to 38. The mean length L(w) as measured by AFIS varies between 0.81 and 1.08 inches with an average of 0.96 inches which is 0.06 inches higher than the results from the Suter-Webb Array analysis. The coefficient of variation CV (%) of L(w) from AFIS varies between 40.4% and 30.8% and also has a tendency to decrease with the longer lengths.

Table 2. AFIS Pro Data

8x8 ID	L(w) (in)	L(w) CV%	SFC(w) (%)
31	0.86	35.6	11.7
32	0.81	40.4	18.5
33	0.91	33.7	8.3
34	0.93	34.4	9.3
35	0.99	31.4	6.6
36	1.03	30.9	6.2
37	1.05	33.0	7.1
38	1.08	30.8	6.0
AVG	**0.96**	**33.78**	**9.21**

The average of the CV's is 33.78% which is quite close to the results from the Suter-Webb Array analysis. The short fiber content SFC(w) % varies from a low of 6% in the 38/32 group to a high of 18.5% in the 32/32 inch group. The short fiber content averaged over all the groups is 9.21%. This value of SFC(w) from AFIS is much smaller (>4%) than the 13.78 % obtained from Suter-Webb Array analysis.

The 8x8 cottons were characterized using the Peyer AL-101 Almeter at the USDA-ARS-SRRC (CSQ) Research Unit was located in New Orleans. Data is based upon averaging the results of five determinations of 75 mg, each. Results shown in Table 3 are again given for each of the eight cottons. The mean length L(w) as measured by the Almeter varies between 0.78 and 1.01 inches with an average of 0.92 inches which is only 0.02 inches higher than the results from the Suter-Webb Array analysis. The coefficient of variation CV (%) of L(w) from the Almeter varies between 37.63% and 27.65% and also has a tendency to decrease with the longer lengths. The average of the CV's is 31.1%, which is quite close to the results from the Suter-Webb Array analysis. The short fiber content SFC(w) % varies from a low of 5.4% in the 38/32 group to a high of 20.3% in the 32/32 inch group. The short fiber content averaged over all the groups is 9.76%. This value of SFC (w) is quite close to AFIS and likewise is much smaller than the 13.78 % obtained from Suter-Webb Array analysis.

The following bar charts are included to allow comparison of how each of the length measurement techniques characterized the three critical length parameters: L(w), L(w) CV%, and SFC(w)%. The measures of L(w) obtained by Suter-Webb Array, AFIS, and Almeter grouped individually, for each of the staple length groups, are shown in Figure 4. It appears that the Almeter results are somewhat closer to Suter-Webb, while AFIS is consistently higher. It is interesting to note that the mean length for length group 32 is slightly smaller than the mean length for length group 31. The measures of L(w) CV% obtained by Suter-Webb Array, AFIS, and Almeter grouped individually, for each of the staple length groups, are shown in Figure 5. The CV% for staple length groups 33 through 38 are all quite close to each other, clustering around 30%. Length group #32 is the exception with the CV%'s clustering around 40%. The CV% for group #31 clusters around 35%. Almeter generally has the lowest CV%, no doubt because it is averaged over 25,000 data points! Similarly, the measures of SFC(w)% obtained by Suter-Webb Array, AFIS, and Almeter grouped individually, for each of the staple length groups, are shown in Figure 6. The SFC(w)% as measured by the S-W Array method for all eight staple length groups are all significantly greater than the measurements using either AFIS or Almeter. Then differences are especially great for groups #31 and #32. Otherwise, AFIS and Almeter are quite close in their measurements of SFC(w)%.

Table 3. Peyer Almeter Data

8x8 ID	L(w) (in)	L(w) CV%	SFC(w) (%)
31	0.81	32.29	14.8
32	0.78	37.63	20.3
33	0.89	29.64	8.1
34	0.93	30.70	9.6
35	0.90	31.69	6.1
36	1.00	27.65	5.4
37	1.01	29.76	6.9
38	1.01	29.47	6.9
AVG	**0.92**	**31.10**	**9.76**

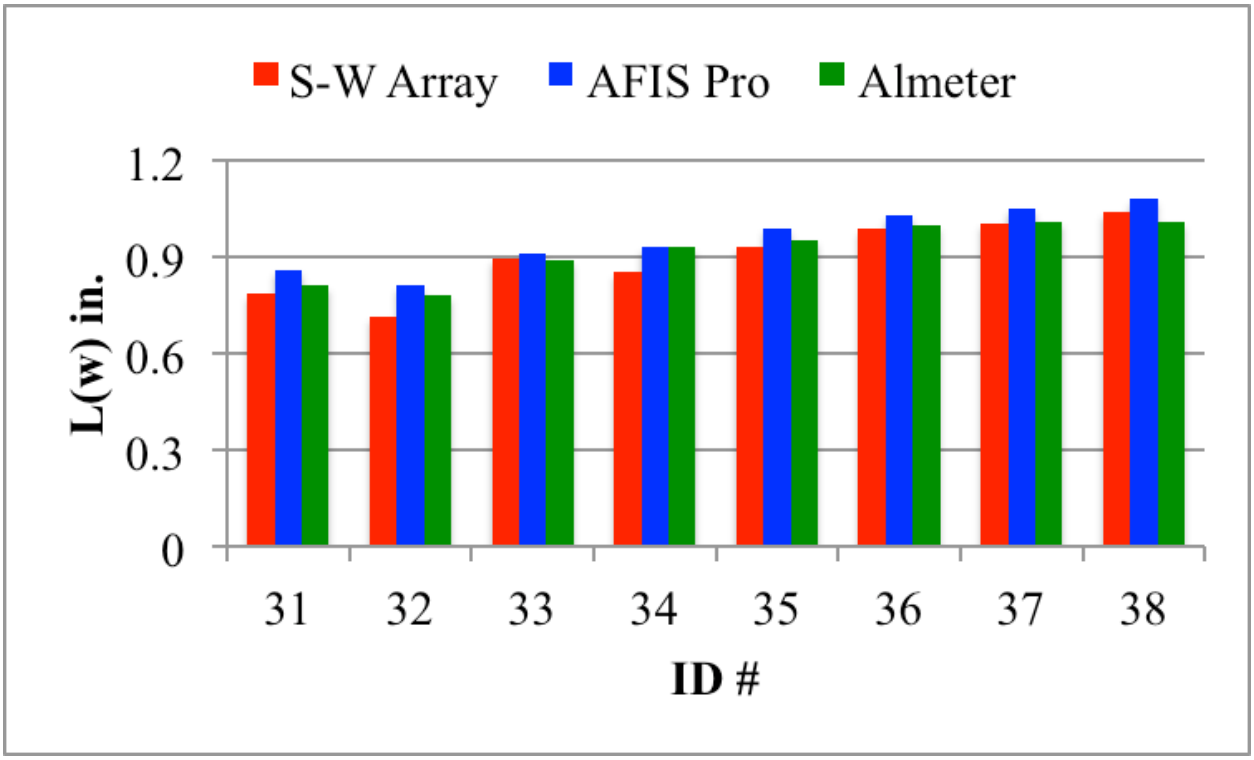

Figure 4. L(w) measured by the three methods.

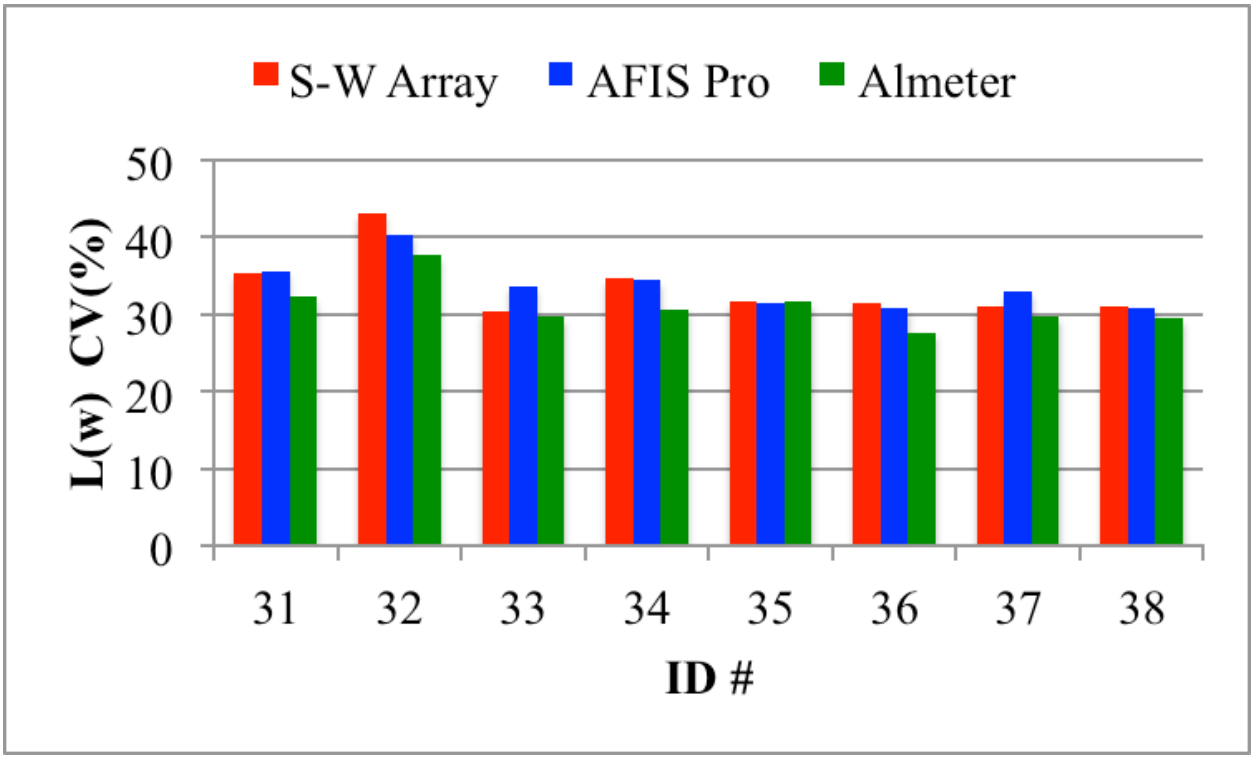

Figure 5. L(w) CV% measured by the three methods.

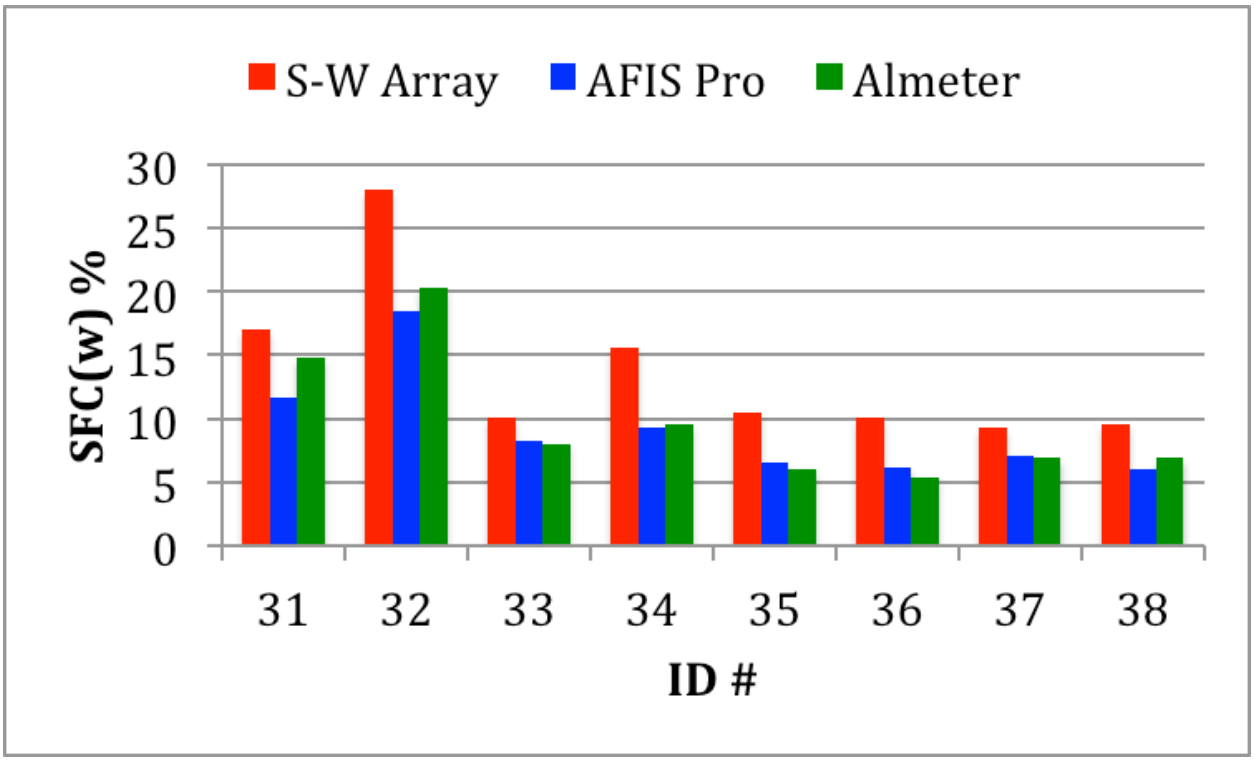

Figure 6. SFC(w)% measured by the three methods.

Summary

- The average for all eight cottons of the mean length by weight [L(w)] for both Peyer and Array are in good agreement but both are less than for AFIS.
- The average for all eight cottons of the short fiber content by weight [SFC(w)] for both Peyer and AFIS are in good agreement but are both less than for the Array Method.
- L(w) for Peyer correlates with L(w) for AFIS and Array methods at $R^2 = 0.90$ and 0.91, respectively but with some differences in slope and offset.
- SFC(w) for Peyer correlates with SFC(w) for both the AFIS and Array methods at $R^2 = 0.85$, but with some differences in slope and offset.
- Frequency distributions for each of the eight cottons for Peyer, Array, and AFIS are all similar , especially for the four shorter cottons.
- We are concerned by the Almeter's poor performance relative to SFC. The problem here may be sample preparation, either:
    - Incomplete removal of neps and trash, or
    - poor end alignment.
- We were more than a little surprised at how well AFIS performed. We all have concerns that AFIS damages fibers in its opening phase. However:
    - It's length is longer than the S-W array.
    - Short fiber SFC is less than S-W.

References

ASTM D1440-07 Standard Test Method for Length and Length Distribution of Cotton Fibers (Array Method).

ASTM D5332-00 Standard Test Method for Fiber Length and Length Distribution of Cotton Fibers (Withdrawn 2006).