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Assessing a Pneumatic Fractionator as a Lint Cleaning Device

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ABSTRACT

A pneumatic fractionator was assessed as a lint cleaning device for ginned lint. Results from a test that used two line pressures and three fractionation times showed that higher line pressure and longer fractionation time produced fiber that was shorter in staple length, contained more neps, and had less dust, trash, and visible foreign matter (including leaf). Short fiber content was not different among fractionator treatments, and all treatments had varying degrees of classer prep calls. The fractionator was effective in removing foreign matter. Overall, the least aggressive treatment had the best fiber properties, and the most aggressive fractionator treatment did the most cleaning. Results from a lint cleaning test that compared the least and most aggressive fractionator treatments with a conventional saw-type lint cleaner showed that the fractionator did not preserve fiber length any better than conventional lint cleaning. The most aggressive fractionator treatment was more effective in removing foreign matter, but had considerably more neps than conventional lint cleaning. The fractionator treatments received prep calls and the conventional lint cleaner treatments did not. The most aggressive fractionator treatment was more harmful to fiber than conventional lint cleaning, and the least aggressive treatment had fiber properties similar to one saw-type lint cleaner. The most aggressive fractionator treatment had the highest cleaning efficiency, largest amount of lint cleaner waste, and lowest bale value. The highest bale value was achieved with either no lint cleaning or with the least aggressive fractionator treatment. Further work is needed to determine the interactions of the fractionator with different cultivars and cottons of varying foreign matter content as well as determine any effects of the fractionator on spinning performance.

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In a previous study, Whitelock et al. (2011) conducted a beltwide gin sampling project in ginning plants across the entire cotton belt to assess changes in Upland cotton quality at different locations throughout the ginning process. In addition to establishing a baseline for cotton quality before and after saw-type lint cleaning for future efforts to address issues with seed coat fragments, short fiber content, and neps, it also reinforced the need to find less damaging methods of removing foreign matter in ginned lint.

In modern ginning plants, foreign matter is removed from ginned lint with air- and saw-type lint cleaners (Mangialardi et al., 1994). Lint cleaning research has centered mostly on saw-type lint cleaners with grid bars (Mangialardi and Anthony, 2003). This type of lint cleaner is efficient at removing foreign material, but reduces fiber length and increases short fiber and nep content. Although work continues on investigating new grid bar designs to mainly reduce seed coat fragments but also improve overall fiber quality (Armijo et al., 2009, 2011, 2013), other work (discussed below), both past and recent, used a pneumatic fractionator to remove foreign matter from ginned lint. The fractionator has been used traditionally as a standard research method to determine foreign matter content in seed cotton (Shepherd, 1972), but its simplicity of not having any moving or fiber-damaging machine parts indicates it might be possible to modify the approach for use in high-speed commercial gins.

Past research used the fractionator as a faster means of determining foreign matter content in ginned lint than the Shirley Analyzer (W.E. Chapman and J.V. Martinez, 1972, Unpublished report). The results showed a positive and highly significant correlation between the fractionator and Shirley Analyzer foreign matter measurements. The time required to process a sample averaged 4 min for the fractionator and 20 min for the Shirley Analyzer. Other past research modified the fractionator to collect fine, bur cotton material and found that an optimum line pressure and fractionation time for this application was 276 kPa (40 psig) and 30 s, respectively (Brashears, 1983), instead of the standard 483 kPa (70 psig).

In a more recent test to evaluate the fractionator as device for cleaning ginned lint, Whitelock et al. (2008) tested the fractionator with line pressure set at 276 kPa (40 psig), the same line pressure used by Brashears (1983). Seven lint cleaning treatments after normal saw ginning were used: no lint cleaning, one standard saw-type lint cleaner, and fractionating for 5, 10, 15, 20, and 30 s. They found that although maintaining fiber quality parameters such as length, short fiber content, and nep count at levels similar to those of lint not subjected to lint cleaning, the fractionator cleaned lint and produced color measurements similar to one saw-type lint cleaner. Varying the fractionation time had little effect on the results. The 2008 study by Whitelock et al. led to another fractionation study that used a cultivar with different fiber properties, an additional (higher) line pressure, and longer fractionation times. Preliminary results by Whitelock et al. (2014) showed that the fractionator performed similar to a typical saw-type lint cleaner.

The objective of this study was to assess a pneumatic fractionator as a lint cleaning device for ginned lint. Fiber quality and lint cleaner waste attributes were determined for the fractionator and conventional saw-type lint cleaning. The information presented in this report details the completion of the preliminary work done by Whitelock et al. (2014).

MATERIALS AND METHODS

Figure 1 shows the pneumatic fractionator used in the experiment. It consisted of a rectangular chamber that measured about 45.7 cm (18 in) tall by 61.0 cm (24 in) wide by 20.3 cm (8 in) deep, had rounded ends at the top and bottom, and was split and hinged in the middle. Compressed air from eight jets situated across the back of the chamber caused the cotton to tumble and flow around the perimeter of the chamber. The tumbling and rubbing action on 0.48-cm (0.1875-in) slots located across the front of the chamber caused trash particles and dust to be dislodged from the cotton. A low-volume air stream pulling on the bottom of the chamber helped foreign matter to exit through the slots. The foreign matter was then collected on a series of two 20.3-cm (8-in) diameter sieves (Tyler No. 6 [3.3-mm (0.13-in) opening] and No. 200 [75-µm (0.0030-in) opening]). The standard method that determines foreign matter content in seed cotton calls for a 483 kPa (70 psig) line pressure and 60 s fractionation time (Shepherd, 1972).

Figure 1. Pneumatic fractionator.

The study was conducted at the USDA-ARS Southwestern Cotton Ginning Research Laboratory in Mesilla Park, NM. ‘FiberMax 989’, a high-quality high-yielding Upland cultivar grown in the Mesilla Valley of southern New Mexico, was used in the study. A saw ginning trial collected lint samples before and after one saw-type lint cleaner. Some of the samples collected before lint cleaning were used to determine the performance of the pneumatic fractionator. The remaining samples were used to compare conventional saw-type lint cleaning with the fractionator. The ginning trial consisted of two levels of seed-cotton cleaning (no cleaning and three seed cotton cleaners) and two levels of lint cleaning (no cleaning and one saw-type lint cleaner). The seed cotton cleaning sequence was a six-cylinder cleaner, stick machine, and six-cylinder cleaner (no drying). The six-cylinder cleaners were gravity-fed, 1.3-m (50-in) wide Continental /Moss Gordon inclines. The stick machine was a gravity-fed 1.8-m (72-in) wide Continental/Moss Gordin Little David cleaner. Ginning was performed on a cut down Continental 46-saw Double Eagle saw gin stand with a Continental /Moss Gordin Galaxie feeder. The lint cleaner consisted of one saw-type Continental/ Moss Gordin Lodestar cleaner.

The fractionator test consisted of two levels of compressed line pressure, 276 and 483 kPa (40 and 70 psig), and three levels of processing time (10, 30, and 75 s) for a total of six fractionator treatments. The 483 kPa (70 psig) line pressure treatment forced more air to flow through the jets causing more aggressive agitation of the cotton sample in the fractionator. The initial weight of lint samples in the fractionator was approximately 50 g (0.11 lb). After processing through the fractionator, weights were recorded for clean lint remaining in the chamber, and material captured on the No. 6 and No. 200 sieves.

Lint samples taken in both the ginning trial and fractionator test were sent to the USDA-AMS Classing Office for official High Volume Instrument (HVI) classing. Lint samples were also analyzed at Cotton

Incorporated with the Advanced Fiber Information System (AFIS, Uster Technologies, Charlotte, NC) and Micro Dust and Trash Analyzer III (MDTA 3, Uster Technologies, Charlotte, NC). Lint cleaner waste was analyzed for foreign matter content with the Shirley Analyzer (ASTM, 2007). The lint portion of the lint cleaner waste that was separated by the Shirley Analyzer was analyzed for AFIS fiber properties.

The experimental design was a randomized complete block with five replications serving as blocks. Analysis of variance was performed with the General Linear Model of SAS at the 5% level of significance (version 9.2; SAS Institute, Inc.; Cary, NC), and differences between main effect treatment means were tested with Tukey's studentized range test.

RESULTS AND DISCUSSION

Although the ginning trial contained two seed cotton cleaning treatments (zero and three cleaners), analysis showed that other than there being two distinct levels of foreign matter in the lint, there were no interactions between seed cotton cleaning and any of the lint cleaning treatments. Therefore, the treatment that contained zero level of seed cotton cleaning was not used when investigating the pneumatic fractionator. This might be more appropriate because a commercial gin plant would always use some level of pre-cleaning.

Tables 1 through 4 summarize the results of the test that processed lint samples through the pneumatic fractionator. As mentioned earlier, these samples were collected immediately after ginning (no lint cleaning treatment) in a separate ginning trial. The tables are arranged by line pressure, fractionation time, and line pressure/fractionation time combinations. Essentially all fiber and waste properties had a nonsignificant cross-product effect with line pressure and fractionation time.

Table 1. Means and statistical analysis of AFIS fiber properties, by line pressure and fractionation time treatment.

Treatment	Length[z]	Length CV[z]	Upper-Quartile Length[z]	Short Fiber Content[z]	Fineness	Immature Fiber Content	Maturity Ratio	Nep	
								Count	Size
	mm	%	mm	%	m-tex	%	-	per g	µm
	---------- Line Pressure[y] ----------								
276 kPa	27.1 a	37.4	33.9 a	9.35	155	5.94	0.87	435 b	722 b
483 kPa	26.4 b	38.7	33.3 b	10.6	154	6.32	0.87	554 a	737 a
	---------- Fractionation Time[y] ----------								
10 s	27.1	37.6	34.0 a	9.50	155	6.03	0.88	438 c	730
30 s	26.8	38.1	33.7 ab	9.98	154	6.08	0.87	499 b	728
75 s	26.3	38.5	33.2 b	10.5	155	6.28	0.87	546 a	732
	---------- Line Pressure/Fractionation Time[y] ----------								
276 kPa/10 s	26.9 ab	38.4	33.9 a	10.2	153	6.32	0.87	392	725
276 kPa/30 s	27.3 a	37.0	34.0 a	8.98	154	5.74	0.88	437	722
276kPa/75 s	27.0 ab	36.9	33.8 a	8.86	156	5.76	0.88	476	720
483 kPa/10 s	27.3 a	36.9	34.0 a	8.80	156	5.74	0.88	484	735
483 kPa/30 s	26.3 ab	39.2	33.3 ab	11.0	154	6.42	0.87	561	734
483 kPa/75 s	25.6 b	40.1	32.6 b	12.1	153	6.80	0.86	617	744
	---------- Observed Significance Level[x] ----------								
Line Pressure	0.0219	NS	0.0051	NS	NS	NS	NS	< 0.0001	0.0013
Frac. Time	NS	NS	0.0121	NS	NS	NS	NS	< 0.0001	NS
L.P. x Frac.	0.0419	NS	0.0420	NS	NS	NS	0.0454	NS	NS

[z] By the weight method.

[y] Means followed by the same letter in each column are not different based on Tukey's studentized range test ($p \leq 0.05$).

[x] NS = not statistically significant at ($p > 0.05$).

Tables 1 and 2 show the AFIS fiber properties of clean lint. Fiber length measurements (by weight) and nep count were different among line pressure and fractionation time (Table 1). Higher line pressure and longer fractionation time produced fiber that was shorter and contained more neps; this was particularly evident in the line pressure/fractionation time treatment combinations. Fiber length decreased 2.6% (27.1 to 26.4 mm) as line pressure in the fractionator increased from 276 to 483 kPa (40 to 70 psig). Upper-quartile length decreased 2.4% (34.0 to 33.2 mm) as fractionation time increased from 10 to 75 s. The shorter fiber lengths with higher line pressure might be attributed to longer fibers escaping through the slots in the fractionator and ending up in the trash. Nep count followed the same unfavorable pattern as fiber length: higher line pressure produced fiber with about 27% more nep counts (554 versus 435 neps per g) and longer fractionation times produced about 25% more neps (546 versus 438 neps per g). More aggressive tumbling of the fiber in the fractionator might have contributed to high nep counts. The shortest fiber length and highest nep count (25.6 mm [1.008 in] and 617 neps per g, respectively) occurred with the 483 kPa/75 s treatment. Short fiber content, fineness, immature fiber content, maturity ratio, and seed coat nep count (Table 2) were not different among line pressure or fractionation time treatment and averaged 9.98%, 155 m-tex, 6.13%, 0.87, and 24.2 counts per g, respectively.

Table 2 shows that AFIS foreign matter measurements of clean lint were different among line pressure and fractionation time treatment. Higher line pressure and longer fractionation time produced fiber that contained lower dust and trash counts and less visible foreign matter. Total trash count decreased from 297 to 183 particles per g (38%) as line pressure in the fractionator was increased from 276 to 483 kPa. Visible foreign matter decreased 66% (1.38 to 0.47 percentage points) as fractionation time increased from 10 to 75 s. It makes sense that the more aggressive treatments removed more foreign matter. The highest total trash count and visible foreign matter (440 counts per g and 1.57%, respectively) occurred with the 276 kPa/10 s (least aggressive) treatment.

Table 3 shows HVI fiber properties of clean lint. Micronaire, strength, and color grade were not different among line pressure or fractionation time treatment and averaged 3.31, 30.5 g/tex (298.6 kN m

Table 2. Means and statistical analysis of AFIS fiber properties, by line pressure and fractionation time treatment.

Treatment	Seed Coat Nep		Dust Count	Trash Count	Total Trash Count	Trash Size	Visible Foreign Matter
	Count	Size					
	per g	µm	per g	per g	per g	µm	%
	Line Pressure[z]						
276 kPa	25.7	1086 b	239 a	56.8 a	297 a	352	1.08 a
483 kPa	22.6	1164 a	149 b	34.1 b	183 b	347	0.72 b
	Fractionation Time[z]						
10 s	27.8	1101	303 a	69.2 a	373 a	352	1.38 a
30 s	23.1	1107	175 b	43.1 b	219 b	351	0.87 b
75 s	21.5	1167	104 c	24.1 c	128 c	344	0.47 c
	Line Pressure/Fractionation Time[z]						
276 kPa/10 s	30.8	1073	358	81.6	440	348	1.57
276 kPa/30 s	22.8	1077	225	55.0	280	354	1.09
276kPa/75 s	23.4	1108	136	33.8	170	353	0.59
483 kPa/10 s	24.8	1129	248	56.8	305	355	1.18
483 kPa/30 s	23.4	1137	125	31.2	157	349	0.65
483 kPa/75 s	19.6	1225	72.4	14.4	87.0	336	0.35
	Observed Significance Level[y]						
Line Pressure	NS	0.0150	< 0.0001	< 0.0001	< 0.0001	NS	< 0.0001
Frac. Time	NS	NS	< 0.0001	< 0.0001	< 0.0001	NS	< 0.0001
L.P. x Frac.	NS	NS	NS	NS	NS	NS	NS

[z] Means followed by the same letter or group of letters in each column are not different based on Tukey's studentized range test ($p \leq 0.05$).

[y] NS = not statistically significant at ($p > 0.05$).

kg^{-1}), and 105, respectively. Upper-half mean length followed closely with AFIS length measurements: higher line pressure and longer fractionation times produced shorter fiber. Upper-half mean decreased from 32.1 to about 31.4 mm (1.264 to 1.236 in.) as line pressure was increased from 276 to 483 kPa and fractionation time went from 10 to 75 s. Uniformity had a significant interaction between line pressure and fractionation time. Uniformity decreased 2.5 percentage points as line pressure and fractionation time were increased from 276 kPa/10s to 483 kPa/75s.

Extraneous matter was different among line pressure and fractionation time treatment. Extraneous matter is defined as prep, bark, grass, seed coat fragments, oil, or spindle twist but not leaf. Extraneous matter is reported as level 1 or 2, with level 2 indicating the heavier contamination. In this case, extraneous matter was preparation or prep (the degree of smoothness or roughness of the lint sample), and all fractionation treatments received a prep call. Prep calls were more frequent as both line pressure and fractionation time increased. All of the longest fractionation time (75 s) replications received level 1 prep calls. One concern about using the fractionator for cleaning lint was that the action of the compressed air jets tumbled the lint without adding the combing effect of the saw-type lint cleaner. As a result, the fiber might appear tangled and receive prep calls when being classed. The important finding was that all fractionator treatments had some calls.

Continuing with Table 3, reflectance increased from 81.6 to 82.0 as line pressure was increased from 276 to 483 kPa, and yellowness ranged from 9.06 to 9.38 among fractionation time treatments. These increases, although statistically significant, were small and did not affect color grade. Leaf grade changed considerably due to line pressure and fractionation time treatment. When line pressure was changed from 276 to 483 kPa, leaf grade improved from 2.5 to 1.9 and as fractionation time was lengthened from 10 to 75 s, it improved from 3.0 to 1.5. Leaf grade ranged from 3.0 with the 276 kPa/10 s treatment to 1.0 with the 483 kPa/75 s treatment. This confirms findings in AFIS fiber measurements that the more aggressive fractionator cleaning treatments took out more foreign material.

Table 3. Means and statistical analysis of HVI fiber properties, by line pressure and fractionation time treatment.

Treatment	Micronaire	Upper-Half Mean Length	Uniformity	Strength	Extraneous Matter	Reflectance	Yellowness	Color Grade[z]	Leaf Grade
	Reading	mm	%	g/tex	Index	Rd	+b	Index	Index
	Line Pressure[y]								
276 kPa	3.30	32.1 a	82.0 a	30.7	0.53 b	81.6 b	9.15 b	11	2.5 a
483 kPa	3.31	31.5 b	80.8 b	30.3	0.87 a	82.0 a	9.36 a	11	1.9 b
	Fractionation Time[y]								
10 s	3.28	32.1 a	82.1 a	30.6	0.40 b	81.3 c	9.06 b	11	3.0 a
30 s	3.31	32.0 a	80.9 b	30.2	0.70 ab	81.8 b	9.38 a	11	2.2 b
75 s	3.33	31.4 b	81.2 b	30.6	1.00 a	82.3 a	9.32 a	11	1.5 c
	Line Pressure/Fractionation Time[y]								
276 kPa/10 s	3.30	32.4 a	82.5 a	30.9	0.20	80.8	8.98	11	3.0 a
276 kPa/30 s	3.30	32.2 a	81.3 abc	30.1	0.40	81.7	9.22	11	2.6 a
276kPa/75 s	3.30	31.9 a	82.4 a	31.0	1.00	82.2	9.24	11	2.0 b
483 kPa/10 s	3.26	31.9 a	81.8 ab	30.3	0.60	81.7	9.14	11	3.0 a
483 kPa/30 s	3.32	31.8 a	80.5 bc	30.3	1.00	82.0	9.54	11	1.8 b
483 kPa/75 s	3.36	30.9 b	80.0 c	30.3	1.00	82.4	9.40	11	1.0 c
	Observed Significance Level[x]								
Line Pressure	NS	< 0.0001	< 0.0001	NS	0.0227	0.0037	0.0001	NS	< 0.0001
Frac. Time	NS	0.0002	0.0019	NS	0.0063	< 0.0001	< 0.0001	NS	< 0.0001
L.P. x Frac.	NS	NS	0.0244	NS	NS	NS	NS	NS	0.0032

[z] Statistical analysis conducted using coded values (see text for explanation).

[y] Means followed by the same letter in each column are not different based on Tukey's studentized range test ($p \leq 0.05$).

[x] NS = not statistically significant at ($p > 0.05$).

Table 4 shows MDTA 3 fiber and trash proportions in the cleaned lint, non-lint content (foreign matter) in the fractionator waste determined by the Shirley Analyzer, and AFIS properties on the portion of fiber that was separated from the fractionator waste with the Shirley Analyzer. The MDTA 3 confirmed earlier AFIS and HVI foreign matter measurements: as fiber is cleaned more aggressively with either higher line pressure or longer fractionation time, more foreign matter is taken out. Trash content as determined by MDTA 3 decreased from 2.18 to 1.40% as line pressure was increased from 276 to 483 kPa, and decreased from 2.64 to 1.12% as fractionation time increased from 10 to 75 s. Trash content ranged from 3.07% with the 276 kPa/10 s treatment to 0.72% with the 483 kPa/75 s treatment. Fiber fragments and dust were not different among line pressure and fractionation time treatments and averaged 0.35% and 0.14%, respectively. AFIS foreign matter had a significant interaction between line pressure and fractionation time. There was a 32% decrease in foreign matter in the lint cleaner waste when line pressure was increased from 276 to 483 kPa, and when fractionation time was increased from 10 to 75 s. The largest proportion of foreign matter in the lint cleaner waste (75.3%) occurred with the 276 kPa/10 s treatment. These results indicated that the lint cleaner waste from the more aggressive fractionator treatments contained a greater percentage of lint.

Table 4 also shows some interesting results of AFIS measurements on fiber in the fractionator waste. When line pressure was increased from 276 to 483 kPa (more aggressive), fiber length in the waste increased from 18.3 to 19.9 mm (0.720 to 0.783 in), upper-quartile length increased from 25.3 to 27.2 mm (0.996 to 1.071 in), and short fiber content decreased from 35.0 to 28.5% (an 18.6 percentage point decrease). This was probably due to the fractionator forcing more and longer fibers through the slots and into the waste with more aggressive, higher pressure, handling. However, the same reasoning did not hold as fractionation time was increased from to 10 to 75 s (also more aggressive handling): fiber length in the waste decreased from 19.5 to 18.9 mm (0.768 to 0.744 in), upper-quartile length decreased from 26.8 to 25.9 mm (1.055 to 1.020 in), and short fiber content increased from 30.3

Table 4. Means and statistical analysis of MDTA 3 fiber properties, Shirley Analyzer foreign matter in the lint cleaner waste, and AFIS fiber properties of the lint portion of the lint cleaner waste, by line pressure and fractionation time treatment.

Treatment	Lint Foreign Matter				Fractionator Waste				
	Lint	Trash	Fiber Fragments	Dust	Foreign Matter	Fiber length	Fiber Length CV	Upper-Quartile Length	Short Fiber
	%	%	%	%	%	mm	%	mm	%
Line Pressure[z]									
276 kPa	97.3 b	2.18 a	0.33	0.15	64.1 a	18.3 b	56.7 a	25.3 b	35.0 a
483 kPa	98.1 a	1.40 b	0.36	0.12	43.7 b	19.9 a	52.7 b	27.2 a	28.5 b
Fractionation Time[z]									
10 s	96.9 c	2.64 a	0.34	0.12	64.4 a	19.5 a	54.1	26.8 a	30.3 b
30 s	98.0 b	1.62 b	0.32	0.11	53.6 b	18.9 b	55.0	26.1 b	32.5 a
75 s	98.4 a	1.12 c	0.36	0.17	43.7 c	18.9 b	55.0	25.9 b	32.4 a
Line Pressure/Fractionation Time[z]									
276 kPa/10 s	96.5	3.07	0.35	0.12	75.3 a	18.5	56.7	25.7	34.2
276 kPa/30 s	97.6	1.96	0.33	0.11	64.7 b	18.2	56.3	25.3	34.9
276kPa/75 s	98.0	1.51	0.30	0.21	52.2 c	18.0	57.2	24.8	35.9
483 kPa/10 s	97.3	2.21	0.34	0.13	53.6 c	20.5	51.5	27.9	26.5
483 kPa/30 s	98.3	1.28	0.31	0.10	42.5 d	19.5	53.7	26.9	30.0
483 kPa/75 s	98.7	0.72	0.42	0.13	35.1 e	19.7	52.8	26.9	28.9
Observed Significance Level[y]									
Line Pressure	<0.0001	<0.0001	NS	NS	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Frac. Time	<0.0001	<0.0001	NS	NS	< 0.0001	0.0010	NS	0.0011	0.0182
L.P. x Frac.	NS	NS	NS	NS	0.0002	NS	NS	NS	NS

[z] Means followed by the same letter in each column are not different based on Tukey's studentized range test ($p \leq 0.05$).

[y] NS = not statistically significant at ($p > 0.05$).

to 32.4% (a 6.9% increase). Fiber lengths and short fiber content interactions were not significantly different between line pressure and fractionation time, so it is not known why fiber length was longer (and short fiber content less) with a more aggressive line pressure but not with longer fractionation times.

Tables 5 through 9 show the results of a comparison between the fractionator and conventional saw-type lint cleaning. For this analysis, only the two extreme fractionator treatment combinations (Tables 1 through 4) were used: 276 kPa (40 psig) line pressure and 10 s fractionation time (276 kPa/10 s), and 483 kPa (70 psig) line pressure and 75 s fractionation time (483 kPa/75 s). The 276 kPa/10 s treatment was the least aggressive of the fractionator treatments and resulted in the best fiber properties, and the 483 kPa/75 s treatment was the most aggressive and did the most cleaning. Conventional lint cleaner treatments consisted of no lint cleaning (No LC) and one saw-type lint cleaner (One LC).

Table 5 shows that AFIS fiber length, length CV, short fiber content, fineness, immature fiber content, and maturity of the cleaned lint were not different among lint cleaning treatments and averaged 26.6 mm (1.047 in), 38.3%, 10.1%, 154 m-tex, 6.10%, and 0.88, respectively. AFIS upper-quartile length and nep count were different among lint cleaning treatments. The 483 kPa/75 s treatment had the shortest upper-quartile length of 32.6 mm (1.283 in), whereas the remaining three treatments were not different and averaged 33.8 mm (1.331 in). Results from both length measurements indicated that the fractionator did not preserve fiber length any better than conventional lint cleaning. With respect to AFIS nep count, the 483 kPa/75 s treatment contained the most neps at 617 neps per g, whereas the One LC and 276 kPa/10 s treatments were not different and averaged 406 counts per g. The No LC treatment contained the fewest neps at 318 counts per g. Thus, nep content increased by an average 27% over no lint cleaning with either the least aggressive fractionator treatment or one saw-type lint cleaner. Nep content with the most aggressive fractionator treatment was 94% greater than no lint cleaning, and an average 52% more than either the least aggressive fractionator treatment or one saw-type lint cleaner. It was surprising that this, albeit most aggressive, fractionator treatment produced more neps that the saw-type lint cleaner.

Table 6 shows that AFIS seed coat nep count, seed coat nep size, and trash size in clean lint were not different among lint cleaning treatment and averaged 27.3 count per g, 1110 µm, and 336 µm, respectively; the remaining foreign matter measurements were different among lint cleaning treatment. AFIS total trash count ranged considerably from 87.0 to 776 counts per g with the 483 kPa/75 s treatment having the lowest count. Total trash count was not different between the 276 kPa/10 s and One LC treatment and averaged 409 counts per g; the No LC treatment had 776 counts per g. AFIS visible foreign matter results were similar to total trash count: fiber from the 483 kPa/75 s treatment contained considerably less foreign matter at 0.35%; the 276 kPa/10 s and One LC treatments were not different and averaged 1.40%. Visible foreign matter was highest with the No LC treatment at 2.36%. It is interesting that the 483 kPa/75 s treatment contained substantially less foreign matter than the 276 kPa/10 s and One LC treatments (79% less in total trash count and 75% less in visible foreign matter). This showed that the fractionator was effective in removing foreign matter.

Table 5. Means and statistical analysis of AFIS fiber properties, by lint cleaner treatment.

Treatment	Length[z]	Length CV[z]	Upper-Quartile Length[z]	Short Fiber Content[z]	Fineness	Immature Fiber Content	Maturity Ratio	Nep	
								Count	Size
	mm	%	mm	%	m-tex	%	-	per g	µm
Lint Cleaning Type[y]									
No LC	27.1	37.3	33.8 a	9.08	155	5.58	0.89	318 c	733
276 kPa/10 s	26.9	38.4	33.9 a	10.2	153	6.32	0.87	392 b	725
One LC	26.8	37.5	33.6 a	9.14	154	5.70	0.88	420 b	717
483 kPa/75 s	25.6	40.1	32.6 b	12.1	153	6.80	0.86	617 a	744
Observed Significance Level[x]									
Lint Cleaner	NS	NS	0.0080	NS	NS	NS	NS	< 0.0001	NS

[z] By the weight method.

[y] Means followed by the same letter in each column are not different based on Tukey's studentized range test ($p \leq 0.05$).

[x] NS = not statistically significant at ($p > 0.05$).

Table 6. Means and statistical analysis of AFIS fiber properties, lint cleaner treatment.

Treatment	Seed Coat Nep		Dust Count	Trash Count	Total Trash Count	Trash Size	Visible Foreign Matter
	Count	Size					
	per g	µm	per g	per g	per g	µm	%
	Lint Cleaning Type[z]						
No LC	31.2	1056	644 a	132.0 a	776 a	325	2.36 a
276 kPa/10 s	30.8	1073	358 b	81.6 b	440 b	348	1.57 b
One LC	27.4	1084	312 b	65.2 b	378 b	334	1.22 b
483 kPa/75 s	19.6	1225	72.4 c	14.4 c	87.0 c	336	0.35 c
	Observed Significance Level[y]						
Lint Cleaner	NS	NS	< 0.0001	< 0.0001	< 0.0001	NS	< 0.0001

[z] Means followed by the same letter or group of letters in each column are not different based on Tukey's studentized range test ($p \leq 0.05$).

[y] NS = not statistically significant at ($p > 0.05$).

Table 7. Means and statistical analysis of HVI fiber properties, by lint cleaner treatment.

Treatment	Micronaire	Upper-Half Mean Length	Uniformity	Strength	Extraneous Matter	Reflectance	Yellowness	Color Grade[z]	Leaf Grade
	Reading	mm	%	g/tex	Index	Rd	+b	Index	Index
	Lint Cleaning Type[y]								
No LC	3.30 ab	32.7 a	82.9 a	31.1	0.0 b	79.0 c	8.76 b	31 b	4.2 a
276 kPa/10 s	3.30 ab	32.5 a	82.5 a	30.9	0.2 b	80.8 b	8.98 b	11 a	3.0 b
One LC	3.22 b	31.6 b	81.7 a	30.8	0.0 b	81.4 b	9.30 a	11 a	2.8 b
483 kPa/75 s	3.36 a	31.1 b	80.0 b	30.3	1.0 a	82.4 a	9.40 a	11 a	1.0 c
	Observed Significance Level[x]								
Lint Cleaner	0.0229	0.0002	0.0004	NS	< 0.0001	< 0.0001	< 0.0001	0.0084	< 0.0001

[z] Statistical analysis conducted using coded values (see text for explanation).

[y] Means followed by the same letter in each column are not different based on Tukey's studentized range test ($p \leq 0.05$).

[x] NS = not statistically significant at ($p > 0.05$).

Table 7 shows that with the exception of strength (which averaged 30.8 g/tex [301.5 kN m kg^{-1}]), all of the HVI fiber property measurements were different among lint cleaning treatments. Micronaire varied slightly and ranged from 3.22 to 3.36 for the One LC and 483 kPa/75 s treatments, respectively. Upper-half mean length and uniformity ranged from 31.1 to 32.7 mm (1.224 to 1.287 in) and 80.0 to 82.9%, respectively. The best fiber length occurred with the No LC and 276 kPa/10 s treatments, which averaged 32.6 mm (1.283 in). Upper-half mean of the One LC and 483 kPa/75 s treatments were not different and averaged 31.4 mm (1.236 in). HVI length results were similar to AFIS results in that the fractionator did not do an appreciably better job of preserving fiber length than conventional lint cleaning. The fiber length uniformity was lowest with the 483 kPa/75 s treatment (80.0%), whereas the other three treatments were not different and averaged 82.4%. Extraneous matter or prep in this case was not present in the No LC and One LC treatments. All of 483 kPa/75 s treatment replications had prep calls and only 20% of the 276 kPa/10 s treatment replications were called for prep. The important point was the fractionator treatments contained prep and the conventional lint cleaner treatments did not. Leaf grade varied considerably and ranged from 1.0 (483 kPa/75 s) to 4.2 (No LC). There was no difference in leaf grade between the 276 kPa/10 s and One LC treatments, which averaged 2.9. This again shows that the fractionator can be effective in removing foreign matter.

Table 7 also shows that reflectance of clean lint ranged from 79.0 (No LC) to 82.4 (483 kPa/75 s), whereas the 276 kPa/10 s and One LC treatments were not different and averaged 81.1. Yellowness averaged 8.87 on the No LC and 276 kPa/10 s treatments, and 9.35 on the One LC and 483 kPa/75 s treatments. Color grades were coded to facilitate statistical analysis. For example, code 100 = color grade 31, code 104 = color grade 21, and code 105 = color grade 11. Color grade was not different among the two fractionator treatments and One LC treatment and averaged 105 old code, or 11 new code. Color grade on the No LC treatment was 102 old code, which placed between a 31 and 21 new code.

Table 8 shows MDTA 3 fiber and trash proportions in clean lint. Fiber fragments were not different among lint cleaner treatment and averaged 0.37%. Dust content ranged from 0.12% (276 kPa/10 s and One LC) to 0.18% (No LC). The No LC treatment had the smallest proportion of lint (95.2%) and largest proportion of trash (4.27%) followed by the 276 kPa/10 s treatment, which had 96.5% lint and 3.07% trash. The One LC treatment contained 97.9% lint and 1.64% trash, and the 483 kPa/75 s treatment was cleanest with 98.7% lint content 0.72% trash. These results agree with earlier AFIS and HVI findings that the 483 kPa/75 s fractionator treatment was effective in removing foreign matter.

Table 8 also shows non-lint content (foreign matter) in the lint cleaner waste determined by the Shirley Analyzer, and AFIS properties on the portion of fiber that was separated from the lint cleaner waste with the Shirley Analyzer (there was no waste from the No LC treatment). Foreign matter in the lint cleaner waste on the 276 kPa/10 s and One LC treatments were not different and averaged 73.3%. The 483 kPa/75 s treatment had the smallest fraction of foreign matter in the lint cleaner waste at 35.1%. AFIS fiber length and upper-quartile length of fiber that was separated from the lint cleaner waste were not different between the One LC and 483 kPa/75 s treatments and averaged 20.1 mm (0.791 in) and 27.3 mm (1.075 in), respectively. Fiber length and upper-quartile length was 18.5 mm (0.728 in) and 25.7 mm (1.012 in), respectively, on the 276 kPa/10 s treatment. Short fiber content was not different between the One LC and 483 kPa/75 s treatment and averaged 27.7%. The 276 kPa/10 s treatment had the largest amount of short fiber (34.2%). These results showed that with more aggressive lint cleaning, a larger proportion of the lint cleaner waste was fiber, the fiber in lint cleaner waste was longer, and the waste contained less short fiber. Similar results were obtained on the fractionator test (Table 4).

Table 9 shows that lint cleaner waste characteristics and cleaning efficiency, turnout, and bale loan value were different among lint cleaner treatments. These results were based on a standard 218 kg (480 lb) bale. Lint wastage was calculated from the fiber portion of lint cleaner waste. The fractionator treatments removed the least and most amount of waste when cleaning which ranged from 2.50% (or 5.44 kg) to 14.2% (or 31.0 kg) of waste per bale for the 276 kPa/10 s and 483 kPa/75 s treatments, respectively. The One LC treatment was between the fractionator treatments at 5.08% (11.1 kg) of lint cleaner waste per bale. The amount of both fiber and short fiber in the lint cleaner waste was different among lint cleaner treatments. The 276 kPa/10 s treatment had the least amount of fiber in lint cleaner waste at 1.35 kg (2.97 lb), whereas the 483 kPa/75 s treatment had the most (an exorbitant) amount of fiber in the waste at 20.1 kg (44.3 lb). The amount of short fiber in the waste followed this same pattern: 483 kPa/75 s had a large amount at 5.81 kg (12.8 lb), but Table 8 showed it had a lower proportion of short fiber than the other fractionator treatments. Cleaning efficiencies were determined from visible foreign matter content of lint samples before and after lint cleaning. Cleaning efficiency ranged considerably from 25.3% for the 276 kPa/10 s treatment to 73.6% for the 483 kPa/75 s treatment and the One LC treatment cleaning efficiency in between. Lint cleaning efficiency and lint wastage are dependent on many variables. In a lint cleaner study that varied combing ratio and feed rate (and kept other variables constant), Baker (1978) found that using a combing ratio of 20 and a feed rate of 1291 kg/m/h (4 bale/h) yielded a cleaning efficiency and lint wastage of 54.2% and 1.00%, respectively. These numbers are comparable to the conventional lint cleaner used in this test, which had about the same combing ratio and feed rate and obtained a cleaning efficiency and lint wastage was of 55.3% and 1.4%, respectively.

Turnout and bale value were different among lint cleaner treatments. Turnout ranged from 29.6% for the 483 kPa/75 s treatment to 34.5% for the No LC treatment. Turnout on the 276 kPa/10s was 0.70 percentage points greater than the One LC treatment (33.5 versus 32.8%). As anticipated, turnout decreased as the lint cleaning became more aggressive and more foreign matter and fiber (weight) were taken out of the lint. Bale value was based on HVI fiber quality measurements and was determined from 2007 to 2008 Commodity Credit Corporation (CCC) loan rates. The lowest bale value ($223.65) occurred with the 483 kPa/75 s treatment. This makes sense because throughout this analysis, the 483 kPa/75 s treatment was the most aggressive. It reduced the foreign matter content from ginned lint the most; removed the largest amount of lint cleaner waste, which contained the most amount of fiber; and received discounts for reduced fiber quality. Conversely, the highest bale value occurred with the least aggressive treatments, No LC and 276 kPa/10 s, which were not different from each other, averaging $255.19. This was 14% greater in value over the 483 kPa/75 s treatment and 3.7% greater than the One LC treatment. Two points can be commented on concerning bale value. First, it might be beneficial to skip lint cleaning when ginning good, clean cotton. And second, the fractionator, operating at a level that does minimum cleaning but does less fiber damage, might have a better return than using one saw-type lint cleaner.

It is interesting that there were almost no fiber quality differences between the 276 kPa/10s fractionator and One LC treatments, but a pronounced difference in the amount of waste that led to greater bale value. Also, analyses of the lint cleaner waste revealed that the fiber in the waste from the 276 kPa/10s fractionator treatment was shorter, was less uniform in length, and contained more short fiber that that from the One LC treatment. In other words, the One LC treatment wasted more and better quality fiber. Further insight might be gained from spinning tests that often show differences in fiber quality that are not detected in raw fiber measurements.

Table 8. Means and statistical analysis of MDTA 3 fiber properties, Shirley Analyzer foreign matter in the lint cleaner waste, and AFIS fiber properties of the lint portion of lint cleaner waste, by lint cleaner treatment.

Treatment	Lint Foreign Matter				Lint Cleaner Waste				
	Lint	Trash	Fiber Fragments	Dust	Foreign Matter	Fiber Length	Fiber Length CV	Upper-Quartile Length	Short Fiber
					%	mm	%	mm	%
	Lint Cleaning Type[z]								
No LC	95.2 d	4.27 a	0.35	0.18 a	-----	-----	-----	-----	-----
276 kPa/10 s	96.5 c	3.07 b	0.35	0.12 b	75.3 a	18.5 b	56.7 a	25.7 b	34.2 a
One LC	97.9 b	1.64 c	0.37	0.12 b	71.3 a	20.4 a	51.3 b	27.7 a	26.5 b
483 kPa/75 s	98.7 a	0.72 d	0.42	0.13 b	35.1 b	19.7 a	52.8 b	26.9 a	28.9 b
	Observed Significance Level[y]								
Lint Cleaner	<0.0001	<0.0001	NS	0.0004	<0.0001	0.0007	0.0033	0.0014	0.0008

[z] Means followed by the same letter in each column are not different based on Tukey's studentized range test ($p \leq 0.05$).

[y] NS = not statistically significant at ($p > 0.05$).

Table 9. Means and statistical analysis of characteristics of lint cleaner waste, and bale value, based on a 218 kg (480 lb) bale, by lint cleaner treatment.

Treatment	Lint Cleaner Waste	Lint Cleaner Waste	Fiber in Lint Cleaner Waste	Short Fiber in Lint Cleaner Waste	Cleaning Efficiency	Turnout	Loan Value
	%/bale	kg (lb)/bale	kg (lb)/bale	kg (lb)/bale	%	%	$/bale
	Lint Cleaning Type[z]						
No LC	-----	-----	-----	-----	------	34.5 a	255.60 a
276 kPa/10 s	2.50 c	5.44 (12.0) c	1.35 (2.97) c	0.46 (1.01) c	25.3 c	33.5 b	254.78 a
One LC	5.08 b	11.1 (24.4) b	3.17 (6.98) b	0.84 (1.85) b	55.3 b	32.8 c	246.18 b
483 kPa/75 s	14.2 a	31.0 (68.4) a	20.1 (44.3) a	5.81 (12.8) a	73.6 a	29.6 d	223.65 c
	Observed Significance Level[y]						
Lint Cleaner	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

[z] Means followed by the same letter in each column are not different based on Tukey's studentized range test ($p \leq 0.05$).

[y] NS = not statistically significant at ($p > 0.05$).

SUMMARY AND CONCLUSIONS

Results from a test that assessed a pneumatic fractionator at two line pressures and three fractionation times showed that higher line pressure and longer fractionation time produced fiber that was shorter in staple length, contained more neps, and had less dust, trash, and visible foreign matter (including leaf). Short fiber content was not different among fractionator treatments, and all treatments had varying degrees of classer prep calls. The fractionator was effective in removing foreign matter. The length of fiber in the lint cleaner waste was longer with higher line pressures but shorter with longer fractionation times; the reason for this reversal was unknown. Overall, the least aggressive fractionator treatment had the best fiber properties, and the most aggressive treatment did the most cleaning.

Results from a lint cleaning test that compared the least and most aggressive fractionator treatments with a conventional saw-type lint cleaner showed that the fractionator did not preserve fiber length any better than conventional lint cleaning. The most aggressive fractionator treatment was more effective in removing foreign matter, but had considerably more neps than conventional lint cleaning. The fractionator treatments contained prep calls and the conventional lint cleaner treatments did not. There was more fiber in the lint cleaner waste and it was longer with the more aggressive lint cleaner treatments, but as expected, this fiber was considerably shorter in length and contained more short fibers than fiber in ginned lint. The most aggressive fractionator treatment was more harmful to fiber than conventional lint cleaning, and the least aggressive treatment had fiber properties similar to one saw-type lint cleaner. The most aggressive fractionator treatment had the highest cleaning efficiency, largest amount of lint cleaner waste, and lowest bale value. The highest bale value was achieved with either no lint cleaning or with the least aggressive fractionator treatment.

The results of this study differed slightly from those found by Whitelock et al. (2008), which found that length measurements of fiber from the fractionator were better than fiber from conventional lint cleaning. Whitelock et al. (2008) also found that fiber from the fractionator contained the same amount of neps as conventional lint cleaning, and fractionation time in the fractionator had little effect on fiber quality. The discrepancies between the study by Whitelock et al. (2008) and this study might be partly explained by the different levels of line pressure and fractionation times used in the separate studies, but to a large part the discrepancies might be attributed to using cultivars with different fiber properties. This study used a cultivar that was considerably longer, stronger, and finer than the one used by Whitelock et al. (2008). This might explain why the results in this study were not affected to a large degree by lint cleaning. This hypothesis requires further testing (which might include stripper cotton) as well as determining any effects of the fractionator on spinning performance in the textile mill.

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