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ENGINEERING AND GINNING

New Lint Cleaner to Reduce Fiber Waste

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ABSTRACT

Several cleaning machines are required to prepare cotton for marketing. One of those machines, the saw-type lint cleaner, improves the appearance of ginned lint by removing foreign matter, motes, cottonseed, and other undesirable material, but it also removes as much or more good fiber as it does undesirable material. One stage of lint cleaning typically removes about 9.1 kg (20 lbs) of material. An experimental lint cleaner (ELC) designed to reduce the loss of good fiber and maintain fiber quality in the bale was developed, patented, and field tested. Studies to validate the operational characteristics of the ELC were conducted at a research facility and a commercial gin. Results at the research gin indicated that about 2.72 kg (6 lbs) of additional good fiber was retained by the ELC compared with standard Sixteen D and 24D lint cleaner models, and there were no significant differences in fiber properties measured from high volume instrumentation (HVI) or the Advanced Fiber Information System (AFIS). The ELC operated for two full seasons at a commercial gin without operational problems and processed about 10,000 bales. HVI and AFIS parameters of the baled lint from the ELC equaled or exceeded those of the standard lint cleaner.

The saw-type lint cleaner has been used for many years in the ginning industry to comb and blend cotton fiber (lint), and to remove motes (aborted ovules), cottonseed, undesirable fiber, and plant parts. The lint from a gin stand or another lint cleaner is formed into a batt on a condenser screen drum and then fed into one or more sets of compression rollers, passed between very closely fitted feed rollers and a feed plate or bar, and then fed onto a saw cylinder (Fig. 1). The teeth of the saw cylinder convey the fibers past several cleaning points commonly called grid bars that are spaced 0.08 cm (0.03 in.) to 0.04 cm (0.06 in.) away from the saw teeth. Good fiber, as well as undesirable material, is ejected at each of these grid bars or cleaning points, and the amount of good fiber increases proportionately as the number of cleaning points increases (Anthony, 1999b; 2000). The amount of material removed by lint cleaning depends on the amount of foreign matter in the cotton, as well as the percentage of motes and the fiber length characteristics. Typically, one stage of saw-type lint cleaning removes about 9.1 kg (20 lbs) of material that includes at least 50% good fiber (Mangialardi and Anthony, 1998).

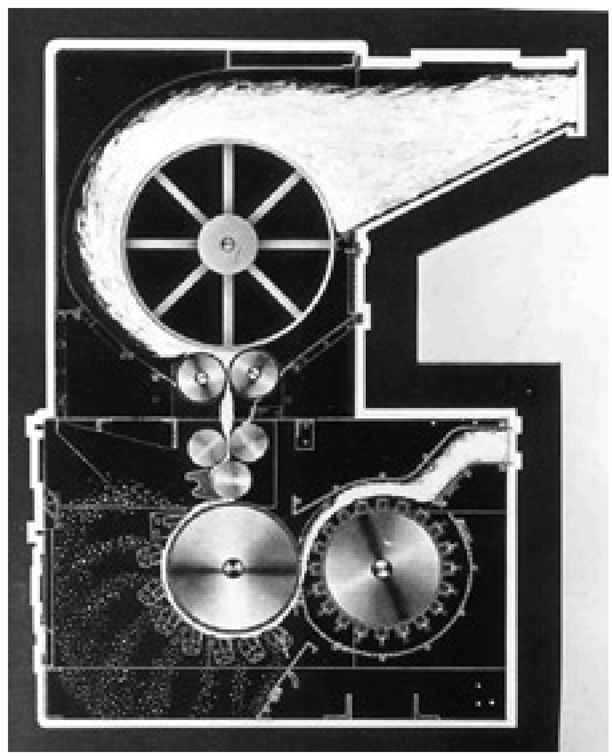

Figure 1. Cross-section of a standard Continental Sixteen D lint cleaner.

The material ejected by lint cleaners is commonly, but erroneously, called "motes" by much of the cotton industry and "lint cleaner waste" by some

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(Anthony, 1999a). It is not unusual for the foreign matter in the lint cleaner waste to represent less than 50% of the total by weight. Lint cleaner waste is typically 1) placed into the waste pile along with materials removed by the seed cotton cleaners, 2) cleaned with a cylinder-type cleaner at the gin and sold to a mote processing facility, or 3) cleaned with cylinder-type cleaners and saw-type lint cleaners at the gin and sold as cleaned "motes". Much of the fiber in the lint cleaner waste is equal in quality to the fiber in the bale and should remain in the bale.

Toward this end, a new machine was developed and patented (Anthony, 2003). The new lint cleaner consists of a standard lint cleaner modified to include a secondary saw to prevent loss of the longer fiber that is ejected by the primary cleaning saw and grid bar arrangement (Fig. 2). The new lint cleaner also includes either a steel brush or splined roller to guide the cotton onto the secondary saw (not shown in Fig. 2). Material from the standard grid bar/saw cylinder falls on the second saw cylinder and is metered and compressed by a powered splined roller or brush. The roller or brush is positioned and operated so that only the longer fiber ejected by the primary saw cylinder is retained by the secondary saw. The first prototype was constructed primarily from used parts from other machinery. Initial tests with the experimental lint cleaner (ELC) were successful (Anthony, 2004).

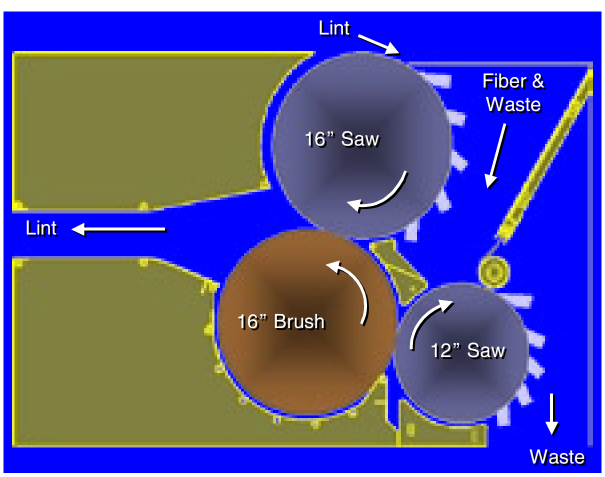

Figure 2. Cross-section of the experimental lint cleaner.

The objectives of this study were to 1) determine the effectiveness of the ELC, and 2) determine the operational suitability of the ELC in a commercial gin.

MATERIALS AND METHODS

Study 1. A completely random experimental design was used for the study and results were analyzed with SAS version 8.2 (SAS Institute; Cary, NC). This study was conducted in the full-scale gin at the Stoneville Ginning Lab and included three machine treatments, two cotton cultivars, and three replications for a total of 18 bales. Each run consisted of processing one bale lots. The machine treatments included 1) the ELC, as described previously, in which the added section of the machine was bypassed to recreate a standard lint cleaner, 2) the ELC equipped with a stationary brush for fiber retention, and 3) the ELC equipped with a powered roller for fiber retention. The cultivars were Stoneville 747 and Stoneville BXN 47 (Stoneville Pedigreed Seed; Memphis, TN) harvested near Stoneville, MS, in 2001. The machine and cultivar treatments were randomly assigned for the study. Sampling included five samples for each of the following: wagon fractionation (module foreign matter), wagon (module) moisture, feeder fractionation (foreign matter before the gin stand), lint moisture before the bale press, and seed coat fragments before the bale press. All moisture samples were analyzed by the oven method (ASTM, 1971) and reported on a wet basis. Ten samples were collected before the bale press for Shirley Analyzer (Shirley Limited; Liverpool, England), HVI (Uster Technologies, Knoxville, TN), and AFIS (Uster Technologies, Knoxville, TN) analyses. Random samples of the lint cleaner waste weighing about 0.454 kg (1.0 lb) were taken from locations in the lint cleaner after it was collected by a battery condenser. Waste samples were taken because retaining 2% additional fiber would not likely be detectable from samples taken from the baled lint, but the differences in the 2% waste fiber should be detectable with the AFIS. Weights for seed cotton, cottonseed, samples, lint, and waste were also taken.

Study 2. The ELC was removed from the full-scale gin at the Stoneville Lab, and installed in E. Ritter Gin at Marked Tree, AR, in August 2002. The Comet Extractor-feeder and a Continental Model 93 gin stand (Continental Eagle Corporation; Prattville, AL) were also removed from the Stoneville Lab and installed in E. Ritter Gin to provide lint to the ELC. Since the E. Ritter Gin was constructed as a “4-less-1” gin plant, the addition of the Stoneville machinery was simplified. The Stoneville equipment was installed for commercial operation during the 2002 season.

During the ginning season, the operational characteristics and the compatibility of the ELC to the commercial environment were observed on 10 occasions. The commercial gin was equipped with three parallel ginning/lint cleaning lines each processing about 15 bales per hour that included the following: Continental Model 9000 Extractor-feeder, Continental model 161 gin stand, Continental Centrifugal Lint Cleaner, and Continental Eagle 24D lint cleaner (all Continental Eagle Corporation; Prattville, AL). The experimental ginning/lint cleaning line processed about 5 bales per hour and included the following: Continental Comet extractor-feeder, Continental model 93 gin stand, and the ELC. Note that the Continental 24D lint cleaner is a newer model than the original version of the Sixteen D lint cleaner used as a basis for the ELC, and includes eight cleaning bars rather than five bars that are used in the Sixteen D. In addition, the saw cylinder diameter is 60.96 cm (24 in.) compared with 40.64 cm (16 in.) for the ELC. Also, note that an air-type lint cleaner was used in the commercial line. Ten paired sets of samples were taken simultaneously after one commercial line and the experimental line on two separate days. Each of the 40 samples were divided into 5 sub-samples and analyzed by HVI at the Dumas Classing Office and by the AFIS at Stoneville. While collecting samples for this study, four samples were taken at each feeder apron for fractionation. Means for the sub-samples were used in the statistical analyses.

Study 3. The ELC and condenser were removed from the commercial gin and returned to Stoneville for refurbishing. Since the original prototype was constructed from used components, several changes were made in preparation for further research at Stoneville and at the commercial gin. Both lint cleaner saws were rewound, the bearings were replaced on the saw and brush cylinder shafts, a new feed bar and first grid bar on the primary saw cylinder were installed, the speed of the splined roller was reduced, the condenser was replaced, and new safety guards were installed.

After the repairs were complete, several bales were ginned to make sure the machine operated properly, and a small test was conducted. The ELC was compared with a Continental Eagle model Sixteen D lint cleaner and a Lummus 66 lint cleaner (Lummus Gin Company; Savannah, GA). Cotton cultivar Stoneville 4892BR (Stoneville Pedigreed Seed) was used in the test. Waste was collected when the machines were operated simultaneously. This evaluation consisted of three replications, each consisting of three bales lots. Five samples each were taken for HVI and AFIS analyses. The amount of material ejected by each lint cleaner was weighed and the weights were adjusted to a 227.3-kg (500-lb) bale basis. Since previous studies had indicated only minor differences in the AFIS variables in the cleaned lint samples, the waste was collected, sampled, and evaluated with the AFIS for fiber length distribution.

Study 4. The renovated ELC was removed from the full-scale gin at the Stoneville Lab and installed in E. Ritter Gin at Marked Tree, AR, in August 2003. During the ginning season, the ELC was compared with the commercial lint cleaners in terms of functionality and operational characteristics on 10 occasions. In addition, 50 samples were collected simultaneously before and after one commercial line and the ELC line for both HVI and AFIS analysis. Sampling was repeated on 3 different days. HVI samples were analyzed at the Dumas Classing Office and the AFIS samples were analyzed at Stoneville. In addition to the lint samples collected, four samples were collected at each feeder apron for fractionation.

RESULTS

Study 1. The data collected during ginning with gin identifications and bale numbers are shown in Table 1 in the order of the ginning treatments. Analyses of variance and means for the ginning related data are shown in Table 2. Ginning rate, wagon fractionation, feeder fractionation, wagon moisture, and lint moisture were not different in the study. Wagon fractionation, feeder fractionation, wagon moisture, and lint moisture averaged 8.8, 3.9, 10.0, and 5.3%, respectively (Table 2). There was a significant difference in lint cleaner waste between machines. The lint cleaner waste removed per 227.3-kg (500-lb) bale ranged from 6.6 kg (14.5 lbs) for the roller treatment to 9.3 kg (20.5 lbs) for the standard machine. Typical waste produced by the Sixteen D and ELC lint cleaners is shown in Figures 3 and 4, respectively. Based on visible observations, the waste emitted by the Sixteen D contained much more fiber than the waste emitted by the ELC.

Table 1. Gin data collected during Study 1

Cotton cultivar [y]	Treatment [z]	Bale weight (kg)	Lint cleaner waste (kg)	Moisture (%)	
				Seed cotton	Lint
STV 747	Brush	214.5	6.55	9.95	5.20
STV 747	Brush	215.9	6.82	10.54	5.45
STV 747	Brush	215.0	7.10	9.33	4.98
STVBXN 47	Brush	248.6	6.63	9.13	4.79
STVBXN 47	Brush	225.0	7.46	9.92	5.27
STVBXN 47	Brush	221.4	5.71	8.76	4.47
STV 747	Roller	249.1	7.33	10.55	7.13
STV 747	Roller	234.1	6.88	11.54	5.46
STV 747	Roller	240.0	6.69	11.44	4.96
STVBXN 47	Roller	missing	5.29	8.84	6.08
STVBXN 47	Roller	213.6	6.67	12.01	5.48
STVBXN 47	Roller	221.4	6.08	9.38	4.82
STV 747	Standard	258.6	9.87	10.37	5.78
STV 747	Standard	194.1	8.73	10.80	5.28
STV 747	Standard	210.0	8.99	8.88	5.12
STVBXN 47	Standard	234.5	9.09	8.40	5.72
STVBXN 47	Standard	219.5	9.27	9.94	5.46
STVBXN 47	Standard	220.9	6.68	9.33	4.74

[y] Stoneville 747 (STV 747) and Stoneville BXN 47 (STVBXN 47).

[z] Sixteen-D lint cleaner with secondary 30.5 cm (12 in.) diameter saw and 5 grid bars (standard), and equipped with either a feed roller (roller) or a stationary brush (brush) to feed waste on to the secondary saw.

Table 2. Analyses of variance and means for the ginning data collected in Study 1

Source of variation [w]	Ginning rate (bales/hr)	Waste			Initial foreign matter (%)	Foreign matter before gin stand (%)	Initial seed cotton moisture (%)	Lint moisture (%)
		Actual (kg)	(%)	Per 227.3-kg bale (kg)				
Machine					Mean [x]			
Standard	4.6	9.10 a	4.10 a	9.33 a	8.67	3.89	9.62	5.35
Brush	4.4	6.71 a	3.01 b	6.85 b	8.68	4.01	9.61	5.03
Roller	4.4	6.49 b	2.91 c	6.61 b	9.12	3.84	10.63	5.66
Mean squares [y]	0.09	61.11**	2.50**	62.58**	0.39	0.04	2.06	0.59
Cultivar					Mean [x]			
STV747	4.6	7.66	3.42	7.77	9.20	4.11	10.38	5.48
STVBXN47	4.4	7.21	3.31	7.52	8.45	3.75	9.52	5.20
Mean squares	0.08	4.44	0.10	2.43	2.59	0.45	3.29	0.36
Machine*cultivar								
Mean squares	0.06	1.36	0.04	1.11	0.05	0.13	0.07	0.04
Statistical model								
Mean	4.5	16.36	3.37	16.83	8.82	3.91	9.95	5.34
P>F	0.59	0.01	0.01	0.01	0.49	0.72	0.22	0.54
CV	6.9	7.54	7.78	7.78	9.74	14.21	9.63	11.54
MSE [z]	0.31	1.23	0.26	1.31	0.86	0.56	0.96	0.62
Residual error	0.10	1.52	0.07	1.72	0.74	0.31	0.92	0.38

[w] Degrees of freedom = 2, 1, 2, and 11 for machine, cultivar, machine*cultivar, and error, respectively.

[x] Means within a column for each independent variable followed by the same letter are not significantly different according to the Waller-Duncan test ($P = 0.05$).

[y] ** = significant at $P \leq 0.01$.

[z] Root mean square error.

Figure 3. Typical waste from a Sixteen D lint cleaner.

Figure 4. Typical waste from the experimental lint cleaner.

There were no significant differences in the AFIS data for machines (Tables 3 and 4), but short fiber content by weight, immature fiber content, fineness, and neps per gram were significantly different between cotton cultivars. The analyses of variance and means for HVI classing data are shown in Tables 5 and 6. There were no significant differences in the classing data for machine or the interaction between machine and cultivar. Leaf, micronaire, reflectance, yellowness, and uniformity were significantly different between cotton cultivars. The Shirley Analyzer for total and visible

Table 3. Analyses of variance and means for AFIS data on fiber characteristics collected in Study 1

Source of Variation [w]	Short fiber content (%)		Immature fiber content (%)	Length by weight (cm)	Upper quartile length by weight (cm)	Length by number (cm)	Length 5% (cm)	Length 2.5% (cm)	Fineness	Maturity ratio	Nep/g	Nep size (mm)
	Weight	Number										
Machine						Mean [x]						
Standard	7.65	25.0	3.30	2.52	3.02	2.03	3.38	3.56	184.8	0.89	238.5	714
Brush	7.67	25.5	3.33	2.52	3.02	2.03	3.35	3.56	183.9	0.89	253.4	716
Roller	7.60	25.0	3.27	2.52	3.02	2.03	3.38	3.56	184.7	0.89	243.8	714
Mean squares	0.01	0.62	0.01	0.01	0.01	0.01	0.01	0.01	1.40	0.01	344.04	8.00
Cultivar						Mean [x]						
STV747	7.22 a	24.36	3.04 a	2.54	3.02	2.06	3.35	3.56	187.4 a	0.90	226.7 a	716
STVBXN47	8.05 b	25.94	3.56 b	2.52	3.02	2.01	3.38	3.56	181.5 b	0.88	263.7 b	7132
Mean squares [y]	3.15**	11.22	1.18**	0.01	0.01	0.01	0.01	0.01	160.80**	0.01	6164.2**	26.40
Machine* cultivar												
Mean squares	0.13	2.50	0.01	0.01	0.01	0.01	0.01	0.01	0.17	0.01**	22.81	43.64
Statistical model												
Mean	7.64	25.15	3.30	1.00	1.19	0.80	1.33	1.40	184.5	0.89	245.2	714
P>F	0.21	0.41	0.03	0.81	0.99	0.57	0.99	0.94	0.01	0.02	0.06	0.44
CV	8.25	7.08	7.57	1.68	1.43	2.61	1.25	1.10	1.19	0.91	8.75	0.70
MSE [z]	0.63	1.78	0.25	0.17	0.02	0.02	0.02	0.02	2.20	0.01	21.46	5.00
Residual error	0.40	3.17	0.06	0.01	0.01	0.01	0.01	0.01	4.85	0.001	460.65	25.05

[w] Degrees of freedom = 2, 1, 2, and 11 for machine, cultivar, machine*cultivar, and error, respectively.

[x] Means within a column for each independent variable followed by the same letter are not significantly different according to the Waller-Duncan test ($P = 0.05$).

[y] ** = significant at $P \leq 0.01$.

[z] Root mean square error.

Table 4. Analyses of variance and means for AFIS data on neps, trash, dust, and visible foreign matter for Study 1

Source of Variation [v]	Seed coat neps/gm (mg)	Seed coat neps size (mm)	Trash and dust/g	Dust size [w]	Dust/g (mg) [w]	Trash/g (mg) [x]	Visible foreign matter (%)
Machine				Mean [y]			
Standard	19	1208 ab	519.8	354.6	417.2	102.8	1.89
Brush	20	1226 a	562.5	351.6	456.2	106.4	1.96
Roller	21	1181 b	596.4	353.3	481.3	115.2	2.14
Mean squares	5.42	3157.59	8825.04	13.56	6269.67	242.05	0.10
Cultivar				Mean [y]			
STV 747	19.91	1203.91	593.9	352.0	479.6	114.4	2.08
STVBXN 47	19.99	1205.64	525.3	354.3	423.5	101.8	1.92
Mean squares	0.03	13.52	21204.27	24.73	14156.84	708.13	0.12
Machine* cultivar							
Mean squares	1.98	3442.31	3404.50	97.62	2550.34	117.94	0.05
Statistical model							
Mean	20.0	1205	559.6	353.2	451.5	108.1	2.00
P>F	0.46	0.06	0.28	0.83	0.24	0.52	0.56
CV	8.66	2.52	14.24	3.12	14.00	16.65	15.87
MSE [z]	1.73	30.37	79.67	11.01	63.21	18.00	0.32
Residual error	2.98	922.29	6347.12	121.12	3995.30	324.07	0.10

[v]Degrees of freedom = 2, 1, 2, and 11 for machine, cultivar, machine*cultivar, and error, respectively.

[w]Smaller than 500 microns but larger than 50 microns

[x]Larger than 500 microns and smaller than 2000 microns

[z]Root mean square error

[y]Means within a column for each independent variable followed by the same letter are not significantly different according to Waller-Duncan test (*P* = 0.05).

Table 5. Analyses of variance and means for HVI classing data collected in Study 1

Source of variation [w]	Staple (cm)	Leaf	Micronaire	Strength (cN/tex)	Reflectance (Rd)	Yellowness (+b)
Machine				Mean [x]		
Standard	2.81	3.69	4.92	29.23	75.70	8.72
Brush	2.81	3.74	4.88	28.98	75.41	8.78
Roller	2.81	3.87	4.90	29.10	74.91	8.76
Mean squares	0.18	0.12	0.002	0.10	0.97	0.01
Cultivar				Mean [x]		
STV 747	2.81	3.89 a	5.06 a	29.27 a	74.77 a	8.91 a
STVBXN 47	2.81	3.58 b	4.74 b	28.93 b	75.91 b	8.60 b
Mean squares [y]	0.03	0.43 **	0.46 **	0.55	5.93 **	0.45 **
Machine* cultivar						
Mean squares	0.03	0.10	0.002	0.16	0.23	0.02
Statistical model						
Mean	2.81	3.73	4.90	29.10	75.34	8.75
P>F	0.14	0.01	0.01	0.50	0.04	0.07
CV	1.25	5.11	2.37	1.41	0.94	2.20
MSE [z]	0.46	0.19	0.12	0.42	0.71	0.19
Residual error	0.21	0.04	0.01	0.17	0.50	0.04

[w] Degrees of freedom = 2, 1, 2, and 11 for machine, cultivar, machine*cultivar, and error, respectively.

[x] Means within a column for each independent variable followed by the same letter are not significantly different according to the Waller-Duncan test (*P* = 0.05).

[y] ** = significant at $P \leq 0.01$.

[z] Root mean square error.

Table 6. Analyses of variance and means for additional HVI classing data and Shirley Analyzer data collected in Study 1

Source of variation [w]	Trash (% area)	Length (cm)	Uniformity	Color grade index	Bark	Shirley analyzer (%)	
						Total	Visible
Machine				**Mean [x]**			
Standard	0.35	2.90	82.91	98.56	9.3	3.88 b	2.30 b
Brush	0.34	2.90	82.56	98.33	11.1	4.11 ab	2.48 ab
Roller	0.41	2.90	82.48	97.20	20.4	4.38 a	2.73 a
Mean squares [y]	0.01	0.01	0.31	3.15	212.62	0.36 *	0.27 *
Cultivar				**Mean [x]**			
STV 747	0.38	2.90	82.96 a	97.36	14.81	4.14	2.57
STVBXN 47	0.35	2.90	82.33 b	98.70	12.35	4.10	2.43
Mean squares [y]	0.003	0.01	1.78 **	8.15	27.43	0.004	0.09
Machine* cultivar							
Mean squares	0.003	0.01	0.01	0.49	459.53	0.04	0.02
Statistical model							
Mean	0.37	1.14	82.65	98.03	13.6	4.12	2.50
P>F	0.18	0.91	0.01	0.38	0.80	0.13	0.07
CV	14.03	1.36	0.39	1.66	179.88	6.69	8.96
MSE [z]	0.05	0.02	0.33	1.62	24.43	0.28	0.22
Residual error	0.003	0.01	0.11	2.63	596.71	0.08	0.05

[w] Degrees of freedom = 2, 1, 2, and 11 for machine, cultivar, machine*cultivar, and error, respectively.

[x] Means within a column for each independent variable followed by the same letter are not significantly different according to the Waller-Duncan test ($P = 0.05$).

[y] * = significant at $P \leq 0.05$; ** = significant at $P \leq 0.01$.

[z] Root mean square error.

waste was significantly different among machines ($P \leq 0.05$). The Shirley Analyzer visible waste was not significant between the standard (2.3%) and brush (2.5%) treatments but was different between the standard and roller treatment (2.7%). There were no significant differences in seed coat fragments between the treatments (Table 7).

Since the marketing parameters were not significantly different, the value per kilogram of cotton in the bale is the same, regardless of the three designs. The difference in total value was only attributed to bale weight. The bale would weigh 2.7 kg (6 lbs) more using the experimental machine treatments that results in over a $4.00 increase in bale value for the farmer based on the 2003 Commodity Credit Corporation loan prices for U.S. cotton. For a typical 30,000 bale per year gin, this would equate to $120,000 annually.

Subsequent to this study, the rotational speed of the feed roller was changed from 31 to about 11 rpm, and the amount of fiber recovered from the lint cleaner waste was dramatically increased. The initial test with the roller at different speeds indicated that the 2.3 kg (5 lbs) of fiber recovered could be increased to at least 3.6 kg (8 lbs).

Study 2. Means for the feeder fractionation samples at E. Ritter Gin were 4.6% and 4.8% for the standard and ELC treatments, respectively. Note that the “standard” lint cleaner for Study 2, was a commercial Continental Eagle Model 9000 extractor-feeder and 161 Model gin stand followed by a Continental Centrifugal Lint Cleaner and a model 24D lint cleaner operated in parallel with the Continental Model Comet extractor-feeder and 93-saw gin stand followed by the ELC. Some significant differences were detected for the AFIS and HVI data mostly in favor of the ELC (Table 8). These variables were primarily related to fiber length distribution, such as short fiber content (7.6% for the commercial versus 6.3% for the ELC). The modified cleaner processed about 5,000 bales during the season without any operational problems.

Table 7. Analyses of variance and means for seed coat fragments per gram of lint collected in Study 1

Source of variation [y]	Seed coat fragments		Motes		Funiculi	
	Count	Weight (mg/g lint)	Count	Weight (mg/g lint)	Count	Weight (mg/g lint)
Machine			**Mean**			
Standard	35.50	21.53	2.33	9.13	2.83	1.03
Brush	43.83	20.64	3.67	15.89	36.56	1.21
Roller	45.67	24.88	3.22	9.06	2.67	1.06
Mean squares	176.17	29.92	2.77	92.26	1.34	0.05
Cultivar			**Mean**			
STV 747	39.93	20.56	3.15	10.79	2.56	0.94
STVBXN 47	43.41	24.14	3.00	11.93	3.48	1.26
Mean squares	54.54	57.72	0.10	5.89	3.86	0.48
Machine* cultivar						
Mean squares	18.71	32.72	2.24	56.38	1.12	0.41
Statistical model						
Mean	41.67	22.35	3.07	11.36	3.02	1.10
P>F	0.27	0.20	0.33	0.16	0.15	0.22
CV	18.64	20.46	40.81	49.40	30.90	37.61
MSE [z]	7.77	4.57	1.25	5.61	0.9.3	0.41
Residual error	60.31	20.92	1.57	31.50	0.87	0.17

[y] **Degrees of freedom = 2, 1, 2, and 11 for machine, cultivar, machine*cultivar, and error, respectively.**

[z] **Root mean square error.**

The differences in marketing parameters did not affect the price per unit of weight, so the difference between the two machines is in the bale weight. For example, the bale would weigh about 2.7 kg (6 lbs) more using the ELC for an increase of about $4.00 based on the 2003 Commodity Credit Corporation loan prices for U.S. cotton.

Study 3. Results for the test conducted after the machine modifications were made indicated that 4.5, 6.6, and 9.6 kg (9.8, 14.6 and 21.1 lbs) of material were removed per 227.3-kg bale by the ELC, Continental Eagle Sixteen D, and the Lummus 66, respectively. Since the modified ELC produced comparatively as much waste as before, the ELC was deemed suitable for a second test at E. Ritter Gin. The ELC was superior to both the Lummus 66 and the Continental Eagle Sixteen D in terms of fiber loss. The small amount of fiber lost by the ELC during ginning is illustrated in Figure 5. Analyses of variance of the cleaned lint samples did not identify any significant differences in HVI or AFIS values.

Subsequent AFIS analysis of the material ejected by the Continental Eagle Sixteen D and the ELC provided the following values for upper quartile, average length of the fibers by weight, and short fiber content, respectively: 2.87 and 2.77 cm; 2.36 and 2.21 cm; and 10.4 and 15.5%. Lower quality material is ejected by the ELC indicating that only the higher quality fiber is retained by the secondary saw of the ELC.

Figure 5. Waste emitted from the experimental lint cleaner during operation at Stoneville.

Table 8. Analyses of variance and means collected in Study 2

Variable	Mean for machine		F-value	Pr > F [z]
	24D	ELC		
Average length by weight (cm)	2.36	2.46	16.03	0.01**
Coefficient of variation (%) of length by weight	33.26	30.13	8.63	0.01**
Upper quartile length by weight (cm)	2.84	2.90	22.50	0.01**
Short fiber content by weight (%)	7.55	6.26	38.77	0.01**
Average fiber length (cm) by number	1.93	2.08	13.40	0.01**
Coefficient of variation (%) of length by number	48.79	42.88	8.62	0.01**
Short fiber content by number (%)	22.51	19.55	22.85	0.01**
Length 5% (cm)	3.20	3.25	16.47	0.01**
Length 2.5% (cm)	3.40	3.48	21.89	0.01**
Fineness (mTex)	177.44	179.61	4.18	0.05**
Immature fiber content (%)	4.27	3.73	9.96	0.01**
Maturity ratio	0.86	0.88	9.38	0.01**
Neps size (μm)	703.1	704.4	0.29	0.59
Neps/g	237.1	225.6	1.97	0.17
Seed coat neps size (μm)	1281	1228	8.41	0.01**
Seed coat neps/g	14	16	10.98	0.01**
Total dust	623.0	685.1	2.00	0.17
Trash size	703.1	704.5	0.22	0.64
Dust (count/g)	513.1	563.8	1.69	0.20
Micronaire	4.48	4.52	0.28	0.60
Strength (cN/tex)	28.34	28.60	1.04	0.31
Reflectance (Rd)	73.00	73.09	0.10	0.75
Yellowness (+b)	9.07	9.05	0.03	0.86
Leaf	3.50	3.77	7.25	0.01**
Trash (% area)	0.05	0.05	0.52	0.48
Length (cm)	2.72	2.74	8.79	0.01**
Uniformity	82.35	82.82	15.95	0.01**

[z] ** = significant at $P \leq 0.01$.

Study 4. Analyses of variance and means for the HVI and AFIS samples taken on 3 different days at the E. Ritter gin at Marked Tree, AR, in October 2003, are reported in Table 9. For the AFIS data, fineness, immature fiber content, maturity ratio, neps per gram, dust per gram, trash per gram, and visible foreign matter were significantly different between machines ($P \leq 0.01$). The neps were higher for the 24D lint cleaner which is likely because the 24D lint cleaner has eight cleaning bars compared to five for the ELC and the differences in ginning rate (15 bales per hour for the commercial line as compared to 5 bales per hour for the experimental line). The higher level of dust in the samples from the 24D and the greater impact on the fineness, immature fiber content, and maturity ratio cannot be explained.

For the HVI data, micronaire, reflectance, and trash percentage area were statistically different. It is most likely that the 24D lint cleaner was more successful in improving the Rd and trash percentage area compared with the ELC, because the 24D has eight cleaning bars compared to five on the ELC. The change in micronaire, fineness, maturity ratio, and neps were in favor of the ELC, whereas the changes in immature fiber content, dust, trash, visible foreign matter, reflectance, and percentage area of trash were in favor of the 24D.

Over 5,000 bales of cotton were cleaned with the ELC in 2003 without any operational or quality problems.

Table 9. Treatment means for the standard 24D lint cleaner and the experimental lint cleaner (ELC)and analyses of variance for changes between the two machines for AFIS and HVI fiber quality parameters collected in Study 4

Variable	Mean for machine		Change for machine		F- value	Pr > F [z]
	24D	ELC	24D	ELC		
Length by weight (cm)	2.36	2.44	-0.018	-0.020	0.14	0.71
Coefficient of variation (%) of length by weight	32.46	30.53	0.25	0.25	0.01	0.99
Upper quartile length by weight (cm)	2.84	2.87	-0.013	-0.015	0.15	0.70
Short fiber content by weight (%)	9.02	7.08	0.39	0.36	0.06	0.81
Average fiber length (cm) by number	1.93	2.03	-0.023	-0.030	0.61	0.44
Coefficient of variation (%) of length by number	48.20	44.82	0.89	0.77	0.13	0.73
Short fiber content by number (%)	26.20	21.91	1.045	0.94	0.08	0.78
Length 5% (cm)	3.20	3.22	-0.013	-0.020	0.71	0.41
Length 2.5% (cm)	3.40	3.43	-0.013	-0.020	0.61	0.44
Fineness	184.0	186.8	-2.9	-0.61	14.73	0.01**
Immature fiber content	3.09	2.86	0.28	0.07	15.06	0.01**
Maturity ratio	0.89	0.90	-0.014	-0.007	9.85	0.01**
Nep/size (μm)	692.1	685.1	-11.5	-8.17	1.08	0.31
Nep/g	201.2	169.1	43.7	30.6	8.70	0.01**
Seed coat neps/size (μm)	1142.8	1155.5	-5.71	21.1	2.13	0.16
Seed coat neps/g	13.1	11.4	1.5	1.29	0.10	0.76
Total dust	314.4	334.7	-260.5	-127.7	29.27	0.01**
Trash size	351.1	368.8	346.4	343.0	0.31	0.58
Dust/g	256.6	265.1	-225.4	-111.1	27.32	0.01**
Trash/g	57.7	69.7	-35.0	-16.5	24.66	0.01**
Visible foreign matter	1.25	1.38	-0.78	-0.32	30.09	0.01**
Micronaire	4.83	4.84	-0.09	-0.01	12.13	0.01**
Strength (cN/tex)	28.5	28.8	-0.26	-0.66	0.68	0.42
Reflectance (Rd)	77.6	76.7	1.75	1.05	8.17	0.01**
Yellowness (+b)	8.1	7.8	0.29	0.22	0.39	0.54
Leaf	2.89	2.99	-0.16	-0.11	0.40	0.53
Trash (% area)	0.03	0.03	-0.03	-0.02	8.06	0.02*
Length (cm)	1.08	1.09	-0.05	-0.05	0.17	0.68
Uniformity	83.0	83.1	-0.59	-0.50	0.42	0.52

[z] * = significant at $P \leq 0.05$; ** = significant at $P \leq 0.01$.

SUMMARY AND CONCLUSIONS

An experimental lint cleaner (ELC) designed to reduce the loss of good fiber and maintain fiber quality in the bale was developed, patented, and tested. Four studies to validate the fiber quality impact and operational characteristics of the ELC were conducted at a research facility and at a commercial gin. Results at the research gin indicated that about 2.7 kg (6 lbs) of additional good fiber was retained by the ELC when compared to a standard Sixteen D lint cleaner with no significant difference in properties measured by HVI or AFIS. The ELC operated for two full seasons at a commercial gin without operational problems and processed over 10,000 bales. HVI and AFIS parameters of the baled lint from the ELC generally equaled or exceeded those of the standard lint cleaner. Based on these four studies, the ELC generally produces fiber of the same quality as conventional Sixteen D and 24D lint cleaners.

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DISCLAIMER

Mention of a trade names or commercial products in the publication is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U. S. Department of Agriculture.

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