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ENGINEERING AND GINNING

Lint Cleaning Performance of a Modified Cylinder Cleaner.

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ABSTRACT

The objectives of these experiments were to evaluate the effectiveness of a modified cylinder cleaner in cleaning lint based on grid bars with a sharp cleaning-edge and compare the performance of one cylinder cleaner to two cylinder cleaners in series operating at one or two speeds. Overall, in comparison to the baseline, saw-type lint cleaner (SLC), cylinder cleaners in various configurations cleaned less efficiently and with less fiber damage. The cylinder cleaner with flat-square edged grid bars had the lowest cleaning efficiency, while the cylinder cleaner with a sharp cleaning edge and narrow gaps cleaned more efficiently. Its waste also contained a larger portion of fiber than that of the flat-square edged grid bars. Turnout of the cylinder cleaners was significantly higher than that of the SLC. Compared to the SLC, these cleaners generated less waste and contained less fiber in their waste.

The impact of adding another cylinder cleaner in lint cleaning was greater than the effect of changing cylinder speed. While turnout from the one cylinder or the two cylinder configuration operating at either one speed or two speeds, was not significantly different from that of the SLC, the waste they generated was much lower.

From these tests, it is concluded that the best alternative to the saw-type lint cleaner for cleaning efficiency and turnout is a configuration comprised of two cylinder cleaners in tandem operated in single speed. One cleaner has grid bars with narrowly spaced sharp cleaning edges and the other cleaner has narrowly spaced flat-square edged grid bars.

There was no interaction between cleaner treatments and cultivars.

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INTRODUCTION

Cotton farmers in the United States have had record harvests in the past few years. Even with drought conditions in 2006, harvest in the U.S. was still quite respectable at 21 million bales (average from 1995/96 to 2007/08 was 19.0 million bales). Unfortunately, the cotton market experienced downward pressure and sales were slow at the beginning of 2007 due to unrealized exports to Asia. It was hoped that the market would recover later in the year, but industry experts were concerned, and cautioned our producers to be more responsive to our customers' needs and more vigilant in improving product quality (Brandon, 2007). To improve fiber quality by reducing fiber damage at the gin, Columbus (1990), and Columbus and Anthony (1991) investigated the feasibility of substituting seed-cotton cleaning for lint cleaning. They found that the same color grade (41, 4 leaf) and higher market prices could be obtained by substituting three additional seed-cotton cleaning cycles before ginning for one stage of lint cleaning after ginning. To increase producer returns, Mangialardi (1994) studied alternative ginning and lint cleaning methods to minimize fiber damage and increase turnout. He proposed cleaning lint with an air-type lint cleaner followed by a revolving-screen lint cleaner and a controlled batt saw-type lint cleaner.

A comprehensive review of lint cleaners by Mangialardi and Anthony (2003) indicated many past research efforts were aimed at developing alternatives to the saw-type lint cleaners typically used for cleaning upland cotton. The saw-type lint cleaners perform two primary functions: to remove leaf particles, seed-coat fragments and trash from ginned lint, and to comb and blend out dark spots in the cotton for a smooth appearance. The cleaners perform these functions better than any other device in the market (Mangialardi, 1994). The trade offs between fiber quality, classer's grade, bale value, and profit to the cotton producers are well documented (Mangialardi, 1972; Anthony et al., 1986; Anthony et al., 2001).

Inclined cylinder cleaners are customarily deployed early in the ginning machinery sequence for seed-cotton cleaning. Columbus and Mayfield (1995) verified that cylinder cleaners were gentler in cleaning and caused less damage to fiber than saw-type lint cleaners, but the grade improvement made by cleaning seed cotton through two cylinder cleaners in series was inferior to a single saw-type lint cleaner.

Whitelock and Anthony (2003) studied the performance of cylinder cleaners in cleaning seed cotton, ginned lint and cleaner waste (motes). They evaluated four different grid-bar designs: the round, flat-squares, sharp-squares, and a perforated screen. The spacing between adjacent bars was 9.5 mm (0.375 in.) or 6.4 mm (0.250 in.). Of the grid-bar configurations deployed to clean lint in the study, the flat-square edged grid bars had the best overall performance in terms of lint cleaning efficiency and lint wastage. The cylinder cleaner equipped with sharp-square edged grid bars operating at 1100 rpm was the most efficient in cleaning lint (29.7%), but it also caused excessive lint wastage. The higher lint loss was attributed to the wide spacing between bars (9.5 mm). The study concluded that cylinder cleaners with flat- and sharp-square grid bars are potentially gentler and more efficient in lint cleaning than other cylinder configurations included in the study. Le (2006) found that cylinder cleaners could be used to increase turnout in cleaning lint and their low cleaning performance could be improved with grid bars with a sharp cleaning edge.

The objectives of this study were to find an optimal pin-type cylinder cleaner configuration for cleaning lint based on grid bars with a sharp cleaning edge and compare the cleaning performances of one and two cylinder cleaners in series operating with cylinders rotating at one speed or with the first three and last three cylinders rotating at different speeds.

MATERIALS AND METHODS

The experiment was conducted at the Cotton Ginning Research Unit in Stoneville, MS. A grid bar with a sharp cleaning edge was formed in the shape of a chisel blade. The experimental grid bars were 1.27 cm (0.5 in.) thick, 2.54 cm (1.0 in.) wide and 25.4 cm (10.0 in.) long. The beveled angle of the grid bars was 45 degrees. The grid bars were hardened then welded to a semi-circular cradle at two different spacings: wide (0.95 cm or 0.375 in.) and narrow (0.64 cm or 0.25 in.). The beveled edge of the grid bar was faced away from the flow of cotton so that the cotton engaged the sharp edge of the grid bars. The cradles were 25.4 cm (10.0 in.) wide and 30.5 cm (12.0 in.) long (figures 1 and 2). Performance of the chisel-shape grid bars was evaluated in three experiments.

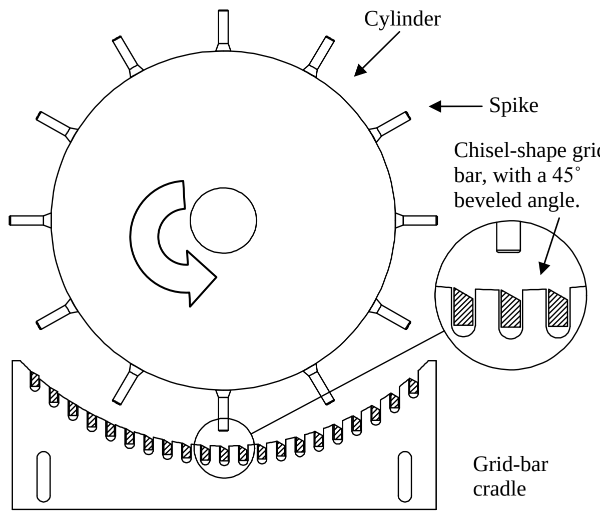

Figure 1. A drawing of the pen-type cylinder cleaner and its grid bar cradle.

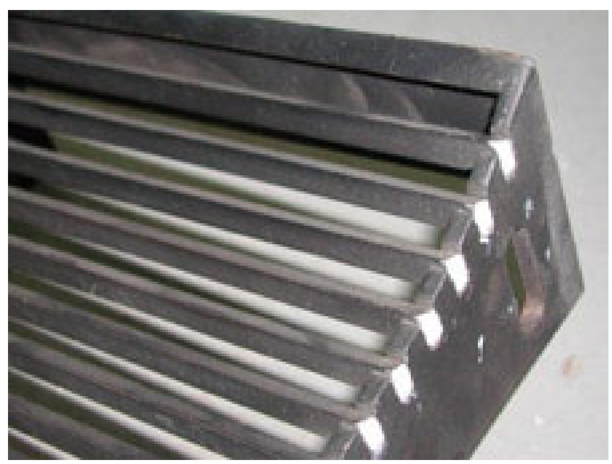

Figure 2. A picture of the chisel-shape grid bar design.

Test 1. Test 1 was designed to evaluate the lint cleaning performance of the chisel-shape grid bars compared to flat-square edged grid bars, and the baseline saw-type lint cleaner (SLC, a reduced width Continental-16D). The test included four different lint cleaner treatments. In treatment 1, the lower three cylinders of the cleaner had narrowly spaced flat-square edged grid bars and the top three cylinders had the widely spaced flat-square edged grid bars (designated as narrow flat + wide flat). This configuration was the best performer in a previous study (Le, 2006). Treatment 2 and 3 were based on the chisel-shape grid bars. The six cylinders of the modified cylinder cleaner in treatment 2 were equipped with three narrowly spaced chisel-shape grid bar cradles in the lower three cylinders and the widely spaced chisel-shape grid bar cradles were installed opposite the top three cylinders (designated as narrow chisel + wide chisel). The modified cylinder cleaner in treatment 3 contained six narrowly spaced chisel-shape grid bar cradles for the six cylinders (designated as narrow chisel). Treatment 4 was the baseline SLC. Throughout Test 1, cylinder and saw speeds were operated at a nominal 1,000 rpm when cleaning ginned lint.

In addition to lint cleaner treatments, a hairy-leaf and a smooth-leaf cultivar were considered in the test. The hairy-leaf cultivar (STV 4892, Monsanto Company; St Louis, MO) was spindle-harvested on October 5, 2005 and the smooth-leaf cultivar (DPL555, Delta Pine and Land Co.; Scott, MS) was harvested on the same day. Approximately 20 lots of nominal 18 kg (40 lb) of seed cotton from each cotton cultivar were prepared for the tests.

The experiment was set up as a split plot design with the lint cleaner treatments as the main units. Seed-cotton cultivars and packing methods formed the 2 x 2 sub-treatment units. With three replications, the experiment required a total of 48 runs.

The ginning sequence for Test 1 consisted of a shelf dryer set at 38 ^{o}C (100 ^{o}F), six-cylinder cleaner, stick machine, six-cylinder cleaner, extractor-feeder, 20-saw (40.6 cm diameter) gin stand followed by the lint cleaner treatments described above. After every extended downtime for configuration changes, 18 kg (40 lb) of seed cotton was run through the system to warm up the machinery before resuming the test.

For each lot ginned, three seed-cotton samples were collected at the feeder apron for foreign matter analysis and three lint samples were collected before and three after the lint cleaner treatments for the Shirley Analyzer (ASTM, 2004, D 2812-98), High Volume Instruments (HVI, Uster Technology, Inc., Knoxville, TN) and Advanced Fiber Information System (AFIS) analyses (Uster Technology, Inc.). Three moisture samples, to be analyzed by the oven drying method (Shepherd, 1972), were also collected after the cylinder or saw-type lint cleaner. The six cylinders of the cleaner were divided into two sections of three cylinders each; each was equipped with a trash pan to collect trash separately.

Test 2. Test 2 was designed to compare the lint cleaning performance of the modified cylinder cleaners to a standard saw-type lint cleaner. The modified cylinder cleaner used in this test had six cradles of narrowly spaced chisel-shape grid bars. Since the operating speed of a cylinder cleaner could affect its cleaning performance (Cocke, 1972), the modified cylinder cleaner was tested at either a single or two different speeds. In the single speed set up, all six cylinders of the cleaner were turning at the same speed (980 rpm). In the dual speed configuration, the speed of the last three cylinders of the cleaner (cylinders 4, 5 and 6) was increased by 20%. The tests also used a hairy-leaf (STV 4892) and a smooth-leaf (DPL555) cultivar. With 3 replications, Test 2 required a total of 18 runs arranged in a randomized complete block design with blocking on replications.

Test 3. Test 3 was designed to evaluate the lint cleaning performance of two cylinder cleaners connected in series to a standard saw-type lint cleaner. As in Test 2, the cleaners were also tested at either one single or two different speeds. In this two cylinder-cleaner configuration, ginned lint was first processed through the modified cylinder cleaner equipped with six cradles of narrowly spaced chisel-shape grid bars followed by a second six-cylinder cleaner equipped with six cradles of narrowly spaced flat-square edged grid bars. When operated at one single speed, the speed of all cylinders was 980 rpm. When operated in dual speeds, speed of the bottom three cylinders of each cleaner was 980 rpm, and speed of the top three cylinders (cylinders 4, 5 and 6) of each cleaner was increased by 20%. Test 3 also used the hairy-leaf (STV4892) and smooth-leaf (DPL555) cultivars. This test was also set up as a randomized complete block experiment with 18 runs.

Both Test 2 and Test 3 adopted the same ginning sequence and sampling plan as used in Test 1.

ANALYTICAL METHOD

Analysis of variance (ANOVA) for all three tests was based on Proc MIXED version 9.1 (Littell et al, 1996) from SAS Institute Incorporated (Cary, NC). When analyzing fiber properties, measurements from samples before the cleaner treatments were included in the model as co-variants for the after treatment responses. Treatment mean comparisons were based on Least Significant Difference (LSD) at probability level of 5% using the LSMEANS procedure in SAS. All main effects for fiber properties of interest were summarized in various tables. In addition to the test of significance based on statistics, significant interactions with less than 5% changes in responses would be inconsequential to consider separately from the main effects.

RESULTS

Moisture content measured from lint samples collected in Test 1 varied from 4.8% to 6.2%, with an average of 5.6% and a standard deviation of 0.3. The average moisture content for lint samples collected in Test 2 was 4.8% with a standard deviation of 0.2. Mean moisture content and standard deviation for lint samples in Test 3 were 5.4% and 0.3, respectively. Moisture content of the samples varied because the tests were conducted in different days and humidity in the Microgin was not controlled. As the treatments were executed in a random order in the replications, there was no apparent bias in the treatments because of moisture variations. Results of other analytical tests were analyzed separately and presented below.

Fiber Properties after Treatments. Results for the HVI properties from all three tests are summarized in Table 1. In comparison to the baseline saw-type lint cleaner treatment (SLC) for all three tests, cylinder cleaner treatments provided significantly lower reflectance and fiber yellowness. Their leaf grade was significantly higher in

Table 1. Summary of HVI properties after cleaner treatments. [z]

Source of variance	Micronaire	Reflectance	Yellowness	Leaf grade	Trash area, %	Length, cm	Uniformity,%
Cleaner treatment [y]				Test 1			
Narrow flat+Wide Flat	4.4	74.9b	9.4ab	3.7a	0.57a	2.80a	81.8
Narrow Chisel+Wide Chisel	4.3	74.9b	9.3ab	3.5a	0.57a	2.79ab	81.9
Narrow chisel	4.4	75.4b	9.2b	3.6a	056a	2.77bc	81.9
SLC	4.4	76.8a	9.5a	3.0b	0.35b	2.76c	81.8
Cultivar							
STV4892	4.5a	74.6b	9.8a	3.6	0.57a	2.82a	82.8a
DPL555	4.2b	76.4a	8.9b	3.3	0.45b	2.74b	80.9b
Cleaner treatment [x]				Test 2			
Two cleaners, 1 speed	4.7	80.4b	7.8b	2.8	0.34a	2.78	81.4
Two cleaner, 2 speeds	4.7	80.4b	7.8b	2.8	0.34a	2.78	81.5
SLC	4.7	80.7a	7.9a	2.5	0.26b	2.81	81.8
Cultivar							
STV4892	4.7	80.5	7.8	2.8	0.31	2.78	81.7
DPL555	4.7	80.5	7.8	2.6	0.31	2.78	81.4
Cleaner treatment [w]				Test 3			
One cleaner, 1 speed	4.7	80.0b	7.8b	3.2a	0.46a	2.83	82.4
One cleaner, 2 speeds	4.7	79.8b	7.8b	3.1ab	0.43a	2.80	82.2
SLC	4.7	80.8a	7.9a	2.5b	0.26b	2.81	82.1
Cultivar							
STV4892	4.7	79.8	8.4a	3.4a	0.46	2.81	83.5a
DPL555	4.8	80.5	7.3b	2.5b	0.32	2.82	81.0b

[z] Means followed by the same letter within a property; or means where letters were not shown, were not significantly different based on Least Significant Differences (LSD) calculated at appropriate degrees of freedom and p= 0.05 level.

[y] Narrow flat+Wide flat = a cylinder cleaner with 3 narrowly spaced flat-square edged grid bar cradles + 3 widely spaced flat-square edged grid bar cradles. Narrow chisel+Wide chisel = a cylinder cleaner with 3 narrowly spaced chisel-shape grid bar cradles + 3 widely spaced chisel-shape grid bar cradles. Narrow chisel = a cylinder cleaner with 6 narrowly spaced chisel-shape grid bar cradles. SLC = saw-type lint cleaner.

[x] Two cleaners, 1 speed = two cylinder cleaners were used for lint cleaning at 980 rpm. Two cleaner, 2 speeds = two cylinder cleaners were used to clean lint; the lower three cylinders of each cleaner was running at 980 rpm and the top three cylinders of each cleaner was running at 1150 rpm.

[w] One cleaner, 1 speed = one cylinder cleaner was used for lint cleaning at 980 rpm. One cleaner, 2 speeds = one cylinder cleaner was used; cylinders 1,2 and 3 were running at 980 rpm and cylinders 4,5 and 6 were running at 1150 rpm.

Test 1 and Test 3 and not different in Test 2. The consistently higher trash amounts produced by the cylinder treatments for all three tests indicated that cylinder cleaner treatments were less efficient in lint cleaning than the SLC. Fiber length produced by the various treatments in Test 1 was different in overlapping ranges. There were no significant differences among cleaner treatments for fiber uniformity and micronaire. Based on HVI properties in Test 1, the three cylinder cleaners with different grid bar installation appeared to perform similarly. In Test 2, the two cylinder treatments produced fiber with lower reflectance and yellowness, and a higher trash amount than the SLC. Other properties were not significantly different. Similarly, in Test 3, significant differences were observed between cylinder cleaner treatments and SLC in reflectance, yellowness, and trash amount. In comparison to the baseline, SLC, cylinder cleaner treatments, with one or two cylinder cleaners operated at one single or two different speeds, produced lower reflectance, fiber yellowness, and higher trash amount. It appeared that many fiber qualities produced by configurations with two cylinder cleaners operated at one or two speeds were similar to those of the SLC. From the trash accumulated in Test 2 and Test 3 in Table 1, it is concluded that the impact of involving an additional cylinder cleaner in the treatment was higher than that of changing cylinder speeds.

ANOVA results for the AFIS properties for all tests are summarized in Table 2. The cleaner treatments in Test 1 did not cause any significant differences in seed coat neps and upper quartile length. The SLC is an aggressive cleaner as it generated

Table 2 . Summary of AFIS properties after cleaner treatments. [z]

Source of variance	Neps/g	Seed coat neps/g	Dust/g	Visible foreign matter, %	Length (w), cm	Short fiber content (w), %	Upper quartile length (w), cm
Cleaner treatment [y]					**Test 1**		
Narrow flat+Wide Flat	188.0b	9.7	574.0ab	2.3a	2.46a	7.87c	2.95
Narrow Chisel+Wide Chisel	197.9b	11.4	523.4b	2.1a	2.46a	7.98bc	2.95
Narrow chisel	196.0b	11.3	588.8a	2.2a	2.46a	8.21b	2.95
SLC	212.5a	11.4	383.1c	1.5b	2.44b	8.50a	2.94
Cultivar							
STV4892	160.0b	13.4a	558.4a	2.4a	2.54a	6.25b	3.00a
DPL555	237.2a	8.5b	476.2b	1.7b	2.37b	10.03a	2.90b
Cleaner treatment [x]					**Test 2**		
Two cleaners, 1 speed	194.3	14.9	167.8a	1.10	2.48	8.13	2.98
Two cleaner, 2 speeds	198.5	16.4	166.3a	1.00	2.48	7.92	2.98
SLC	192.3	16.3	140.4b	0.91	2.48	7.76	2.98
Cultivar							
STV4892	191.2	16.5	159.5	0.99	2.47	8.00	2.98
DPL555	199.0	15.2	156.8	1.02	2.49	7.87	2.98
Cleaner treatment [w]					**Test 3**		
One cleaner, 1 speed	164.6	17.0	241.3a	1.5a	2.59	7.63	3.00
One cleaner, 2 speeds	169.1	17.6	187.7b	1.2b	2.49	7.73	2.98
SLC	176.8	17.7	130.0c	0.8c	2.49	7.94	2.99
Cultivar							
STV4892	145.8b	22.5a	190.4	1.4a	2.51a	6.61	3.00
DPL555	210.1a	12.4b	182.3	1.0b	2.47b	8.93	2.99

[z] Means followed by the same letter within a property; or means where letters were not shown, were not significantly different based on Least Significant Differences (LSD) calculated at appropriate degrees of freedom and p= 0.05 level.

[y] Narrow flat+Wide flat = a cylinder cleaner with 3 narrowly spaced flat-square edged grid bar cradles + 3 widely spaced flat-square edged grid bar cradles. Narrow chisel+Wide chisel = a cylinder cleaner with 3 narrowly spaced chisel-shape grid bar cradles + 3 widely spaced chisel-shape grid bar cradles. Narrow chisel = a cylinder cleaner with 6 narrowly spaced chisel-shape grid bar cradles. SLC = saw-type lint cleaner.

[x] Two cleaners, 1 speed = two cylinder cleaners were used for lint cleaning at 980 rpm. Two cleaner, 2 speeds = two cylinder cleaners were used to clean lint; the lower three cylinders of each cleaner was running at 980 rpm and the top three cylinders of each cleaner was running at 1150 rpm.

[w] One cleaner, 1 speed = one cylinder cleaner was used for lint cleaning at 980 rpm. One cleaner, 2 speeds = one cylinder cleaner was used; cylinders 1,2 and 3 were running at 980 rpm and cylinders 4,5 and 6 were running at 1150 rpm.

more neps and short fiber content than the other cylinder cleaner treatments. It also cleaned more efficiently as its dust and AFIS Visible Foreign Matter (VFM) values were lower. In Test 2, dust produced by the cylinder treatments was the only property significantly different than that by the SLC. In Test 3, dust and VFM were the two properties impacted by cleaner treatments. The SLC was the most efficient cleaner with lower dust and VFM values. These properties indicated cylinder cleaners were less effective and aggressive in cleaning. However, the differences in most fiber properties due to cleaner treatments were small.

There were no observable differences due to the speed effect for either cleaner treatment with one cylinder cleaner (Test 3) or two cylinder cleaners in series (Test 2), except in leaf grade, dust and VFM (tables 1 and 2). There were differences between cylinder cleaner treatments and the baseline SLC in dust (Test 2 and Test 3) and VFM (Test 3). These properties reflected the cleaning efficiency of the cleaner treatments, and the SLC was the more effective cleaner.

Lint Turnout, Waste, and Cleaning Efficiency. Results for turnout, cleaner waste and cleaning efficiency are summarized in Table 3. All three cylinder cleaner treatments achieved higher turnout than the SLC. The largest potential gain achievable by the cylinder cleaners was 1.3%, which amounted to 8.9 kg (19.5 lb based on 1500 lb of seed cotton) of fiber

Table 3. Summary of Turnout, cleaning efficiency, and characteristics of cleaner waste. [z]

Source of variance	Turnout, %	Cleaning efficiency, %	Cleaner waste, kg/bale	Cleaned lint in waste, %	Visible waste in waste, %
Cleaner treatment [y]			**Test 1**		
Narrow flat+Wide Flat	39.4a	12.5c	1.82c	8.6d	87.0a
Narrow Chisel+Wide Chisel	39.0a	16.2b	2.83b	21.0b	75.8c
Narrow chisel	39.0a	15.9b	2.20c	12.0c	84.1b
SLC	38.1b	50.3a	6.77a	51.2a	46.9d
Cultivar					
STV4892	38.7b	23.9	3.47	21.9b	74.8a
DPL555	39.1a	23.5	3.35	24.5a	72.2b
Cleaner treatment [x]			**Test 2**		
Two cleaners, 1 speed	42.3	21.0b	2.41b	20.5b	76.8a
Two cleaner, 2 speeds	42.0	19.5b	2.81b	20.9b	76.0a
SLC	41.4	55.7a	8.75a	53.2a	45.4b
Cultivar					
STV4892	41.6	28.5b	4.60	31.5	66.0
DPL555	42.2	35.6a	4.72	31.6	66.1
Cleaner treatment [w]			**Test 3**		
One cleaner, 1 speed	41.9	12.6b	1.36b	14.1b	84.5a
One cleaner, 2 speeds	42.7	16.7b	1.40b	13.0b	83.4a
SLC	41.5	52.3a	7.59a	55.6a	43.2b
Cultivar					
STV4892	41.2b	28.7	3.50	26.5	71.4
DPL555	42.9a	25.6	3.40	28.7	69.3

[z] Means followed by the same letter within a property; or means where letters were not shown, were not significantly different based on Least Significant Differences (LSD) calculated at appropriate degrees of freedom and p= 0.05 level.

[y] Narrow flat+Wide flat = a cylinder cleaner with 3 narrowly spaced flat-square edged grid bar cradles + 3 widely spaced flat-square edged grid bar cradles. Narrow chisel+Wide chisel = a cylinder cleaner with 3 narrowly spaced chisel-shape grid bar cradles + 3 widely spaced chisel-shape grid bar cradles. Narrow chisel = a cylinder cleaner with 6 narrowly spaced chisel-shape grid bar cradles. SLC = saw-type lint cleaner.

[x] Two cleaners, 1 speed = two cylinder cleaners were used for lint cleaning at 980 rpm. Two cleaner, 2 speeds = two cylinder cleaners were used to clean lint; the lower three cylinders of each cleaner was running at 980 rpm and the top three cylinders of each cleaner was running at 1150 rpm.

[w] One cleaner, 1 speed = one cylinder cleaner was used for lint cleaning at 980 rpm. One cleaner, 2 speeds = one cylinder cleaner was used; cylinders 1,2 and 3 were running at 980 rpm and cylinders 4,5 and 6 were running at 1150 rpm.

per bale or $9.75 per bale (based on $0.50 per 454g of fiber) in revenue if lint grade value was not considered. Turnout produced by cleaner treatments in Test 2 and Test 3 were not significantly different. Cleaning efficiency of the SLC in all three tests was at least three times higher than that of the cylinder cleaners and its waste was also three times higher. The proportion of fiber and visible trash in the waste were measured by a Shirley Analyzer. Waste from the SLC contained the most fiber (51.2% of waste) and the cylinder cleaner configuration, narrow flat + wide flat, contained the least for Test 1 (8.6% of waste).

Waste from the cylinder cleaner in Test 1 was collected in two different trash pans (a pan for the lower three cylinders and another pan for the top three cylinders). For the narrow flat + wide flat and the narrow chisel + wide chisel configurations, the lower pan collected waste from the narrowly spaced flat-square edged or narrowly spaced chisel-shape grid bar cradles, and the top trash pan collected waste from the widely spaced flat-square edged or chisel-shape grid bar cradles. Tables 4 and 5 summarize characteristics of the waste collected from the cylinder cleaner treatments in Test 1 arranged according to grid-bar types. The flat-square edged grid-bar configuration produced the least amount of waste and waste generated by the other configurations equipped with the chisel-shape grid bars was higher. Table 5 shows that the fiber content in the waste of the widely spaced chisel-shape grid bar was the highest and that of the narrowly spaced flat-square edged grid bars the lowest. Wide-gap grid bars lost more fiber than the narrow-gap grid bars, and the sharp (chisel-shape) grid bars lost more fiber than the flat-square edged grid bars, which also cleaned less efficiently. There was no significant interaction effect between cleaner treatments and cultivars.

CONCLUSION

The objectives of the experiments were to evaluate the effectiveness of the chisel-shape grid bars and performance of cylinder cleaners in cleaning ginned lint. Overall, in comparison to the baseline SLC, cylinder cleaners in various configurations cleaned less efficiently and less aggressively. Among cylinder cleaners, the cleaner with flat-square edged grid bars was the least aggressive, with slightly longer fiber and

Table 4. Means of fiber content in the cleaner waste in Test 1 [z]

	Waste A (bottom 3 cylinders)			Waste B (top 3 cylinders)		
Lint cleaner treatments [y]	Total waste per bale, kg	% fiber	% visible waste	Total waste per bale, kg	% fiber	% visible waste
Narrow flat + wide flat	1.8b	3.2c	91.7a	2.8b	14.0b	82.4a
Narrow chisel	3.3a	11.4b	84.7c	2.4c	12.7b	83.6a
Narrow chisel + wide chisel	3.4a	10.8a	85.6b	3.9a	31.1a	66.0b

[z] Means followed by the same letter within a property; or means where letters were not shown, were not significantly different based on Least Significant Differences (LSD) calculated at appropriate degrees of freedom and p= 0.05 level.

[y] Narrow flat + wide flat = the modified cylinder cleaner had three narrowly spaced flat-square edged grid bar cradles followed by three widely spaced flat-square edged grid bar cradles. Narrow chisel = the modified cylinder cleaner had six narrowly spaced chisel-shape grid bar cradles. Narrow chisel + wide chisel = the modified cylinder cleaner had three narrowly spaced chisel-shape grid bar cradles followed by three widely spaced chisel-shape grid bar cradles.

Table 5. Fiber content in the waste of bottom and top cylinders [z]

Cleaner treatments [y]	Fiber content, %	Visible waste, %
Wide chisel	31.1a	66.0c
Wide flat	14.0b	82.4b
Narrow chisel	11.6c	84.6b
Narrow flat	3.2d	91.7a

[z] Means followed by the same letter within a property; or means where letters were not shown, were not significantly different based on Least Significant Differences (LSD) calculated at appropriate degrees of freedom and p= 0.05 level.

[y] Wide chisel = a cylinder cleaner configuration with widely spaced chisel-shape grid bar cradles, Wide flat = a cylinder cleaner configuration with widely spaced flat-square edged grid bar cradles, Narrow chisel = a cylinder cleaner configuration with narrowly sapced chisel-shape grid bar cradles, Narrow flat = a cylinder cleaner configuration with narrowly spaced flat grid bar cradles.

lower short fiber content. Its cleaning efficiency was the lowest (12.5%) among cleaner treatments. The chisel-shape grid bars with a sharp cleaning edge cleaned more efficiently (16.2 and 15.9%). They also generated slightly shorter fiber and had higher short fiber content, but not more neps. Waste from this cylinder cleaner with chisel-shape grid bars contained more fiber in proportion than that of the flat-square edged grid bars. The cylinder cleaner with narrowly spaced flat-square edged grid bars had the lowest short fiber content and the SLC had the highest. Turnout of the cylinder cleaners was significantly higher than that of the SLC. These cleaners generated less waste and contained less fiber in their waste.

Results of Test 2 and Test 3 show that the impact of adding a second cylinder cleaner was greater than the effect of changing cleaner(s) speeds in lint cleaning effectiveness. Leaf grade and trash amount due to the two-cylinder treatments were lower than those generated by the one-cylinder treatments. The comparisons used properties of the SLC as the basis. The effect of cylinder speed changes was not observable in all fiber properties examined. Although turnout from the one-cylinder or the two-cylinder configurations was not significantly different from that of the SLC, their cleaning efficiency was much lower, however the waste generated was also much lower than that of the SLC.

From these tests, it is concluded that the best alternative to the saw-type lint cleaner for cleaning efficiency and turnout is a configuration comprised of two cylinder cleaners operated at a single speed and connected in series. One cleaner has narrowly spaced sharp cleaning edges and the other cleaner has narrowly spaced flat-square edged grid bars.

There was no interaction between cleaner treatments and cultivars.

DISCLAIMER

Mention of a trade mark, warranty, proprietary product or vendor does not constitute a guarantee by the U. S. Department of Agriculture and does not imply approval or a recommendation of the product to the exclusion of others that may be suitable.

REFERENCES

American Society for Testing and Materials (ASTM). 2004. Standard test method for non-lint content of cotton. ASTM Standard D 2812-98. 07.01:670-674. Annu. Book of ASTM Standards. West Conshohocken, PA: ASTM.

Anthony, W. S., R. V. Baker and S. E. Hughs. 1986. Ginning for maximum grade without excessive short fibers, neps, and trash. The Cotton Gin and Oil Mill Press. 87(3):14-17.

Anthony, W. S., D. Van Dorn, E. Pearson, T. J., Malloum, I., Kechagia, U., Ozdemir, and D. Nyoni. 2001. Impact of ginning on fiber quality: The best ginning practices. Report of an expert panel on ginning methods. International Cotton Advisory Committee. Washington, D. C.

Brandon, H. 2007. International Market—Cotton Fiber Length Uniformity Concerns Mills. Delta Farm Press. 64(13) 17. Clarksdale, MS. Prism Bus. Med., Inc.

Cocke, J. B. 1972. Effect of processing rates and speeds of cylinder-type cleaners on ginning performance and cotton quality. ARS 42-199. Washington, D.C.:USDA.

Columbus E. P. 1990. Seed cotton cleaning versus lint cleaning Proc. BeltwideCotton Prod. Res. Conf., Las Vegas, NV. 9-14 Jan. 1990. : Natl. Cotton Counc. Am., Memphis, TN. Columbus E. P. and W. S. Anthony. 1991. Feasibility of seed-cotton cleaning for lint cleaning. Trans. of ASAE. 34(6): 2340-2344.

Columbus E. P. and W. D. Mayfield. 1995. Can seed-cotton cleaners replace the second stage of lint cleaning? The Cotton Gin and Oil Mill Press. 96(2).

Le, S. 2006. Cleaning performance of modified cylinder cleaners. The Journal of Cotton Science. 10:273-283 [online]. Available at http://www.cotton.org/journal/2006-10/4/273.cfm.

Littell, R. C., G. A. Milliken, W. W. Stroup, and R. D. W. 1996. SAS System for Mixed models. Cary, NC: SAS Institute, Inc.

Mangialardi, Jr. G. J. 1972. Multiple lint-cotton cleaning: Its effect on bale value, fiber quality, and waste composition. U.S. Dept. Agr. Tech. Bull. No. 1456. Washington, D.C.: USDA.

Mangialardi, Jr., G. J. 1994. Development of a lint-cleaning concept to preserve fiber quality. Proc. Beltwide Cotton Prod. Res. Conf. , San Diego, CA. 5-8 Jan. 1994.Natl. Cotton Counc. Am., Memphis, TN.

Mangialardi, Jr., G. J. and W. S. Anthony. 2003. Review and summation of lint cleaners for cotton gins. The Cotton Foundation & National Cotton Ginners Association. Memphis, TN.

Shepherd, J. V. 1972. Standard procedures for foreign matter and moisture analytical tests used in cotton ginning research. Agriculture Handbook No. 422. Washington, D.C.:USDA.

Whitelock, D.P. and W. S. Anthony. 2003. Evaluation of cylinder cleaner grid-bar configuration and cylinder speed for cleaning of seed cotton, lint and lint cleaner waste. Applied Engineering in Agriculture. 19(1): 31-37.