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ENGINEERING AND GINNING

Performance of a Modified Cylinder Cleaner, Part I

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ABSTRACT

Inclined cylinder cleaners are used primarily for cleaning upland seed cotton. Previous studies have shown that these cleaners are generally less aggressive than saw-type lint cleaners when used for cleaning lint. The objective of this study was to evaluate the seed cotton and lint cleaning performances of a modified cylinder cleaner equipped with grid bars in the shape of chisel blades. The cleaner's seed cotton and lint cleaning performances were evaluated in two tests, three different cleaner configurations, and two cultivars (smooth- and hairy-leaf). The three cleaner configurations studied included: a baseline saw-type lint cleaner, and two cleaner configurations based on a modified cylinder cleaner with narrowly (6.4 mm) or widely spaced (9.5mm) sharp cutting grid bars, respectively. Ginned lint cleaned by the modified cylinder cleaner was also cleaned by a special saw-type lint cleaner with only one cleaning grid bar. In comparison to the performance of the saw-type lint cleaner, ginned lint cleaned by the modified cylinder cleaner with narrowly spaced grid bars could potentially gain a maximum of 6.4 kg/bale of fiber without compromising color and other fiber properties. Both cylinder cleaners generated more neps in the bale than the standard saw-type lint cleaner. There was no significant interaction between seed-cotton and lint cleaner treatments on fiber properties and other performance measures. The grid bars with a sharp cutting edge cleaned seed cotton more efficiently than the flat-square grid bars.

In comparison to the hairy-leaf cultivar, the smooth-leaf cultivar had higher fiber strength, reflectance, neps and short fiber content. It produced lower seed-coat neps, fiber length, fineness and maturity ratio. The smooth-leaf cultivar was generally easier to clean and insensitive to cleaner treatments.

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INTRODUCTION

Saw-type lint cleaners (SLC) are widely used for cleaning upland cotton. Their cleaning efficiencies are in the range of 45-54%, depending on cotton cultivars, harvesting seasons, methods of harvesting and other growing conditions (Mangialardi and Anthony 2003). SLCs also cause fiber damage and increase short fiber content (Anthony et al., 1986). The trade offs between fiber quality, classer's grade, bale value and profit to the cotton producers are well documented (Columbus, 1990; and Anthony et al., 2001). To overcome many of the saw-type cleaner deficiencies, namely fiber damage, increased nep counts, fiber loss to wastage and over-cleaning, Mangialardi and Anthony (2003) reviewed more than 30 different models and types of lint cleaners. Mangialardi (1994) described a concept that included a flow-through air cleaner after the gin stand, followed by a revolving screen/inclined cylinder cleaner and one stage of saw-type lint cleaning.

Inclined cylinder cleaners are customarily deployed early in the ginning sequence for upland seed-cotton cleaning. Columbus and Mayfield (1995) showed that cylinder cleaners were gentler in cleaning and caused less fiber damage than saw-type lint cleaners, but the grade improvement of two cylinder cleaners in series, was inferior to a single saw-type lint cleaner. Columbus and Anthony (1991) found that the same color grade and higher market prices could be obtained by replacing the second stage of saw-type lint cleaning with three additional stages of seed-cotton cleaning before ginning.

Whitelock and Anthony (2003) studied the cleaning performance of cylinder cleaners. They investigated four different grid-bar designs. The four basic grid-bar shapes considered were round, flat-squares, sharp-squares, and a perforated screen. The spacing between adjacent bars was 6.4 mm (0.250 in.) or 9.5 mm (0.375 in.). The width of the grid bars also varied from 6.4 mm (0.250 in.) or 9.5 mm (0.375 in.). The cylinder cleaner was used to clean seed cotton, ginned lint and lint cleaner waste. The cylinder cleaner with sharp-square grid bars, which operated at 1100 rpm, was the most efficient in lint cleaning (29.7%), but had excessive lint wastage. The flat-square grid bars had the best performance in terms of best lint cleaning efficiency with the least fiber wastage. Although the sharp-square grid bars were the most efficient in cleaning lint, they also lost more fiber to wastage than the flat-square grid bars. The authors attributed the higher fiber loss 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.

This author (Le, 2006) systemically investigated the lint cleaning performance of cylinder cleaners with different grid-bar spacings and shapes, and various combinations of cylinder and saw-type lint cleaners. The study found that a cylinder cleaner with narrowly spaced grid bars (6.4 mm) had smaller total opening (area between grid bars) and yielded higher turnout, but lower cleaning efficiency. The cleaning performance of a modified cylinder cleaner with three widely spaced (9.5 mm) grid-bar cradles followed by special saw-type lint cleaner with one cleaning point came close to the performance of a saw-type lint cleaner, but its turnout was also lower. The total opening of this configuration was 60% of that of the 6 cylinders/cradles with narrow gaps. The study revealed the critical role of balancing the number of cleaning points and total opening in turnout and cleaning performance. It also suggested that sharp cleaning points would improve cleaner performance.

Hence, the objective of this study was to design a grid bar with a sharp cutting edge and evaluate its seed-cotton and lint cleaning performances in a modified cylinder cleaner.

MATERIALS AND METHODS

Test 1: To obtain a sharp cutting edge in the grid bars, the leading edge of the grid bar was beveled at a 45 degree angle in the shape of a chisel blade. The beveled edge of the grid bars was faced away from the flow of cotton so that the cotton would engage the sharp edges of the grid bars. 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 grid bars were installed in a semi-circular cradle. A six-cylinder cleaner required a set of six grid-bar cradles. The cradles were 25.4 cm (10.0 in.) wide and 30.5 cm (12.0 in.) long (figures 1-2). The two grid-bar sets made had narrow (6.4 mm or 0.25 in.) and wide (9.5 mm or 0.375 in.) spacings between grid bars, respectively. A cradle with widely spaced grid bars contained 21 grid bars (53.1 cm^2 open area), while a narrowly spaced version contained 26 grid bars (43.9 cm^2 open area).

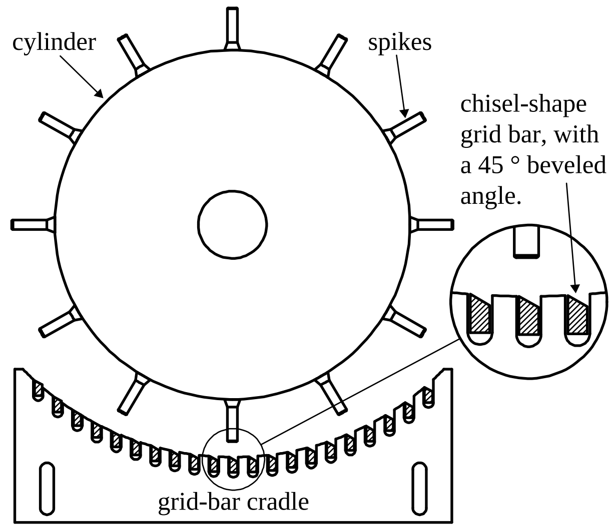

Figure 1. A CAD drawing of the grid bar cradle detailing the shape and beveled angle of the grid bars.

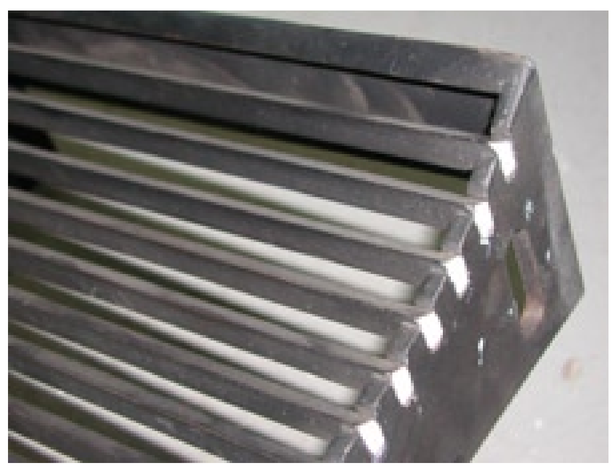

Figure 2 . A close-up view of the chisel-shape grid bars: 12.7 mm wide and 6.4 mm spacing.

Performance of the new grid bars was evaluated in two experiments at the Stoneville Cotton Ginning Laboratory, MS. Test 1 was designed to evaluate the lint cleaning performance of the chisel-shape grid bars compared to a standard SLC. Lint cleaner treatments were refined from Le's study (2006) as follows: treatment 1 and 2 included a modified cylinder cleaner equipped with the newly designed chisel-shape grid bars plus a special saw-type lint cleaner with only one cleaning point. Treatment 1 contained narrowly spaced chisel-shape grid bars. Treatment 2 used only three cylinders and three cradles that contained the same type of grid bars with wide spacings. The remaining three cylinders were blanked out so as to reduce the overall grid bar openings to improve turnout. Treatment 3 was the baseline saw-type lint cleaner (SLC). Both cylinder and saw speeds were set at a nominal 1,000 rpm.

In addition to lint cleaner treatments, two spindle-harvested cotton cultivars were tested in Test 1. They were the hairy-leaf cultivar (STV 4892, Monsanto Company; St Louis, MO) and the smooth-leaf cultivar (DPL555, Delta Pine and Land Co.; Scott, MS). Approximately 20 lots of seed cotton at nominal 18.1 kg (40 lb) were prepared from each cotton cultivar. The cotton was either packed into mesh bags by hand or by a suction pipe, which conveyed the seed-cotton from a trailer to an overhead separator and dropped them into mesh bags.

To assure homogeneity within treatments, a split plot design was used. Its main units were lint cleaner treatments and the sub units were formed by the 2x2 combinations between seed-cotton cultivars and packing methods. The experiment was replicated three times and required a total of 36 runs. However, by judiciously omitting two runs in each replicate, while optimizing the interactions between lint cleaner treatments and packing methods, the experiment was reduced to 30 runs. This resulted in an unbalanced analysis of variance for the experiment in which some treatment combinations had two replications. Proc MIXED (Littell, 1996) of SAS (SAS Institute; Cary, NC) would account for the variance imbalance in its calculations.

The ginning sequence for Test 1 consisted of a shelf dryer set at 38 °C (100 °F), six-cylinder cleaner, stick machine, six-cylinder cleaner, extractor-feeder, and a 20-saw (40.6 cm diameter) gin stand followed by the lint cleaner treatments described above (figure 3). For every extended downtime due to configuration changes, 18.1 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 and three lint samples were collected before and 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 cylinder cleaner was divided into two sections of three cylinders each; trash was collected from each section separately.

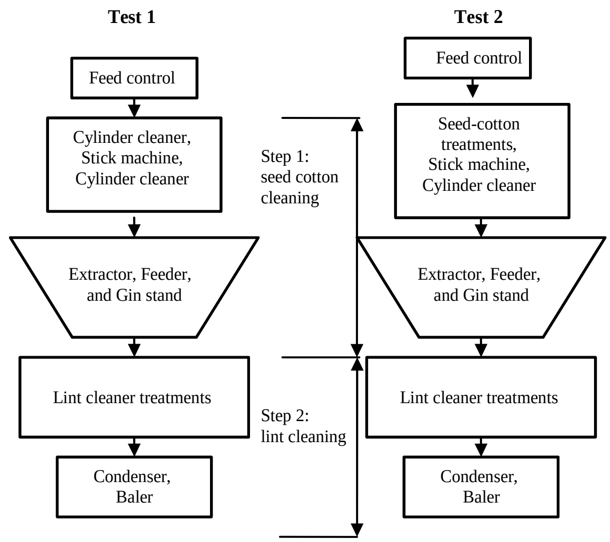

Figure 3. Ginning sequence and equipment used in Test 1 and Test 2.

Test 2: Test 2 was designed to evaluate effectiveness of the chisel-shape grid bars in the cleaning of seed cotton and ginned lint. Test 2 was set up in two separate steps: step 1 for seed-cotton cleaning and step 2 for ginned lint cleaning. In step 1 the same ginning sequence and equipment as used in Test 1 was deployed, except the conventional cylinder cleaner was replaced by a modified cylinder cleaner subjected to three different sets of grid-bar (Figure 3) treatments. In step 2 cleaned seed cotton collected from step 1 was processed through the gin stand followed by the lint cleaner treatments designed for lint cleaning performance evaluations.

The grid bars used for the three seed-cotton cleaning treatments in step 1 were: narrowly spaced (6.4 mm) flat-square grid bars (Figures 4 and 5), narrowly spaced (6.4 mm) chisel-shape grid bars, and widely spaced (9.5 mm) chisel-shape grid bars. The chisel-shape grid bars in narrow or wide spacings were also used in lint cleaner treatments 1 and 2, respectively. SLC was the third treatment. As in Test 1, two cultivars and two seed-cotton packing methods were also included in the test.

Test 2 was set up as a split plot design. The seed-cotton cleaner treatments in step 1 were the main units and lint cleaner treatments in step 2 were the sub units. The 2x2 combinations between cultivars and packing methods were the sub-sub units. All units were blocked and executed in a random order. The test was replicated three times and run in different orders. By taking advantage of the pooled variance from the first two replicates, one cultivar was used in the first two replicates and a second cultivar was used in the third replicate. This experiment design reduced the number of runs required for the experiment and created an unbalanced analysis of variance, which was accounted for in Proc MIXED's calculations (Littell, 1996). The experiment was increased to 54 runs. The sampling plan was the same as used in Test 1 with the additions of collecting three seed-cotton samples before and after the seed-cotton treatments in step 1.

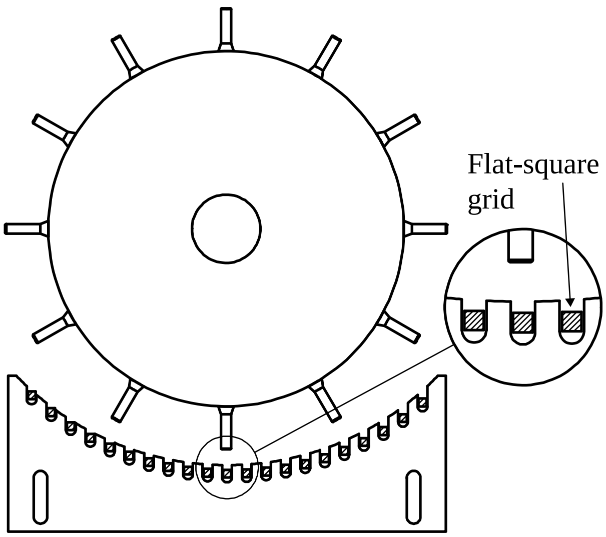

Figure 4. A CAD drawing of the grid bar cradle detailing the square grid bars.

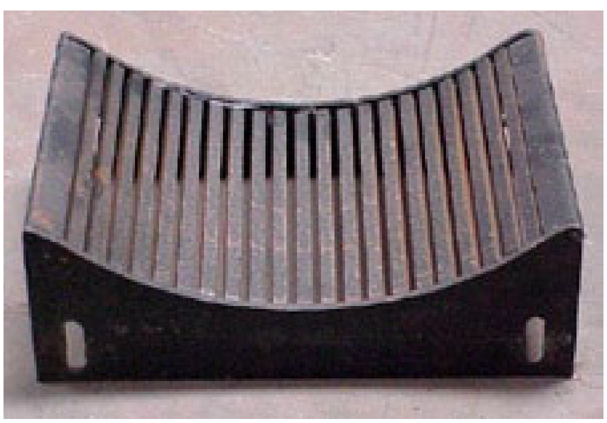

Figure 5. picture of the flat, square grid bar: 9.5 mm wide and 6.4 mm spacing.

Analytical method: Analysis of variance (ANOVA) was based on Proc MIXED from SAS. When analyzing fiber properties, measurements from samples before the treatments were included in the model as covariates for the after treatment responses. Treatment mean comparisons were based on Least Significant Difference (LSD) and the LSMEANS procedure in SAS. All main effects for fiber properties of interest were summarized in various tables, whereas properties affected by significant interaction effects were listed only if the change in the responses from the interaction was greater than 5%.

The seed cotton packing methods were embedded in the designed experiment to test for its variability. Its effects were analyzed and no major differences were found. These results would not be presented in this report, which focused discussion mainly on the objective of the experiment, cleaning performances of the grid bar design.

RESULTS

Moisture content measured from lint samples collected in Test 1 varied from 3.7% to 4.7%, with an average of 4.2% and a standard deviation of 0.28. Moisture content for lint samples collected in Test 2 varied from 3.6 to 5.6%, with an average of 4.9% and a standard deviation of 0.44. Results of other analytical tests were analyzed separately and presented below.

Fiber properties after treatments: Results for the HVI properties from Test 1 and Test 2 are summarized in Tables 1 and 2. Table 1 shows that of all HVI properties from these tests, lint cleaner treatments made a significant difference in reflectance, leaf grade, percent trash area, and fiber length. The SLC reflectance values were the highest and significantly different from both cylinder cleaners. SLC produced higher fiber yellowness, and lower leaf grade and trash.

Results for the AFIS properties in both tests are summarized in Tables 3 to 5. For the lint cleaner treatments in Test 1, lint cleaned by the two cylinder cleaner treatments (narrowly and widely spaced chisel-shape grid bars) had higher nep density than lint cleaned by SLC. By normalizing neps to that of the before treatment, SLC's low nep ratio seemed to imply that it generated fewer neps than the two cylinder cleaner treatments. Test 2 provided the same results. These observations would be further explored in a later section, when fiber in the waste was considered. Seed-coat neps from Test 2 followed a similar nep formation trend, although its ratio was indifferent in comparison. It had been reported that gin stand and lint cleaners generated neps and seed-coat neps (Mangialardi and Griffin, 1966 Mangialardi, 1972). Results from this test showed that lint cleaned by cylinder cleaners had higher nep and seed coat nep densities. Lint cleaned by SLC contained fewer neps and seed coat neps. SLC was the most efficient cleaner among the lint cleaner treatments based on its low dust particles and Visible Foreign Matter (VFM). The cylinder cleaner with narrowly spaced chisel-shape grid bars cleaned slightly better than its widely spaced counter part due to lower dust counts. There were no significant differences in fiber length, upper quartile length, short fiber content, fineness and maturity ratio due to seed-cotton and lint cleaner treatments.

Interaction effects: Leaf grade in Test 1 (Table 2) was the only HVI property that had a significant interaction effect with response changes greater than 5%. The interaction between lint cleaner treatments and cultivars showed that leaf grade for the hairy-leaf cultivar was sensitive to lint cleaner treatments, while that of the smooth-leaf cultivar was not.

There was no significant interaction for AFIS properties in Test 1. In Test 2, seed-coat neps (Table 5) were affected by the lint cleaner treatments and cultivars interaction with response changes greater than 5%. Overall, the hairy-leaf cultivar had more seed-coat neps than the smooth-leaf cultivar for all lint cleaner treatments. For the hairy-leaf cultivar, the cylinder cleaner with narrowly spaced chisel-shape grid bar created the most amounts of seed-coat neps followed by the widely spaced grid-bar configuration and SLC.

Table1. Summary of HVI properties after cleaner treatments. [z]

Source of variance	Micronaire	Strength, g/tex	Reflectance	Yellowness	Leaf grade	Trash area, %	Length, cm	Uniformity,%
Test 1								
Lint cleaner treatments [y]								
Narrow, chisel	4.28	28.6	75.1b	8.5	3.2 a	0.040b	2.75	81.2
SLC	4.33	28.4	76.1a	8.6	3.0 b	0.035c	2.75	81.1
Wide, chisel	4.30	28.4	75.3b	8.5	3.3 a	0.046a	2.76	81.3
Cultivar								
STV4892	4.70	28.6	73.9b	9.0a	3.4 a	0.043	2.76	82.0a
DPL555	3.90	28.3	77.1a	8.0b	3.0 b	0.038	2.76	80.4b
Test 2								
Seed-cotton treatments [x]								
Narrow, flat	4.4	28.0b	75.2a	8.6	3.7a	0.049	2.76b	81.6
Narrow, chisel	4.4	28.5a	75.0ab	8.6	3.6a	0.048	2.76b	81.6
Wide, chisel	4.4	28.2ab	74.8b	8.6	3.4b	0.046	2.77a	81.6
Lint cleaner treatments [y]								
Narrow, chisel	4.4	28.2	74.8b	8.6a	3.6a	0.047b	2.77	81.4
SLC	4.3	28.3	75.5a	8.7a	3.4b	0.039c	2.77	81.7
Wide, chisel	4.4	28.3	74.7b	8.5b	3.7a	0.056a	2.77	81.6
Cultivar								
STV4892	4.3a	28.1	74.0b	8.9a	3.7a	0.049	2.77	82.3
DPL555	4.4b	28.3	76.0a	8.3b	3.4b	0.046	2.77	80.8

[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 difference (LSD) calculated at appropriate degrees of freedom and p= 0.05 level.

[y] Lint cleaner treatments: Narrow, chisel = a cylinder cleaner with narrowly spaced chisel-shape grid bars followed by a special saw-type lint cleaner with one cleaning point. SLC = saw-type lint cleaner. Wide, chisel = a cylinder cleaner with widely spaced chisel-shape grid bars followed by a special saw-type lint cleaner with one cleaning point.

[x] Seed-cotton treatments: Narrow, flat = a cylinder cleaner with narrowly spaced flat-square grid bars. Narrow, chisel = a cylinder cleaner with narrowly spaced chisel-shape grid bars. Wide, chisel = a cylinder cleaner with widely spaced chisel-shape grid bars.

Table 2. Means of HVI properties with interaction. [z]

Source of variance interaction y	Leaf
Test 1	
Narrow, chisel*DPL555	3.0
SLC*DPL555	3.1
Wide, chisel*DPL555	3.0
Narrow, chisel*STV4892	3.4b
SLC*STV4892	3.0c
Wide, chisel*STV4892	3.7a
Test 2	None

[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 difference (LSD) calculated at appropriate degrees of freedom and p= 0.05 level.

[y] Narrow, chisel = a cylinder cleaner with narrowly spaced chisel-shape grid bars followed by a special saw-type lint cleaner with one cleaning point. SLC = saw-type lint cleaner. Wide, chisel = a cylinder cleaner with narrowly spaced chisel-shape grid bars followed by a special saw-type lint cleaner with one cleaning point.

Table 3. Summary of AFIS properties after cleaner treatments. [z]

Source of variance	Neps/g	Nep ratio[w]	Seed-coat neps/g	Seed-coat nep ratio[w]	Dust/g	Visible foreign matter, %
Test 1						
Lint cleaner treatments [y]						
Narrow, chisel	289.2a	1.38a	12.7	1.09	387.1ab	1.79a
SLC	260.8c	1.21b	11.6	0.99	342.4b	1.31b
Wide, chisel	275.3b	1.34a	12.1	1.09	412.7a	1.95a
Cultivar						
STV4892	206.0b	1.25b	14.4a	1.09	403.0	1.79a
DPL555	344.2a	1.36a	9.9b	1.05	358.5	1.57b
Test 2						
Seed-cotton treatments [x]						
Narrow, flat	248.6b	1.26	12.0	1.01	401.8	1.83
Narrow, chisel	253.8ab	1.26	12.9	1.00	412.9	1.86
Wide, chisel	262.5a	1.32	13.1	1.06	399.2	1.90
Lint cleaner treatments [y]						
Narrow, chisel	260.0a	1.33a	13.0ab	1.01	423.9ab	1.95b
SLC	245.2b	1.21b	11.7b	0.97	352.1b	1.55c
Wide, chisel	262.8a	1.30ab	13.4a	1.09	438.0a	2.09a
Cultivar						
STV4892	205.2b	1.25	15.3a	1.04	417.1	2.06
DPL555	304.2a	1.31	10.1b	1.00	392.1	1.67

[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 difference (LSD) calculated at appropriate degrees of freedom and p= 0.05 level.

[y] Lint cleaner treatments: Narrow, chisel = a cylinder cleaner with narrowly spaced chisel-shape grid bars followed by a special saw-type lint cleaner with one cleaning point. SLC = saw-type lint cleaner. Wide, chisel = a cylinder cleaner with widely spaced chisel-shape grid bars followed by a special saw-type lint cleaner with one cleaning point.

[x] Seed-cotton treatments: Narrow, flat = a cylinder cleaner with narrowly spaced flat-square grid bars. Narrow, chisel = a cylinder cleaner with narrowly spaced chisel-shape grid bars. Wide, chisel = a cylinder cleaner with widely spaced chisel-shape grid bars.

[w] Nep ratio = neps/g after treatment / neps/g before treatment, Seed-coat nep ratio = seed-coat neps/g after treatment / seed-coat neps/g before treatment.

Table 4. Summary of AFIS properties after cleaner treatments. [z]

Source of variance	Length(w), cm	Upper quartile length(w), cm	Short fiber content(w), %	Fineness, mTex	Maturity ratio, %
Test 1					
Lint cleaner treatments [y]					
Narrow, chisel	2.42	2.90	8.48	167.8	0.869
SLC	2.42	2.90	8.41	167.9	0.870
Wide, chisel	2.42	2.90	8.42	167.8	0.869
Cultivar					
STV4892	2.43	2.92a	7.23b	179.3a	0.892a
DPL555	2.40	2.88b	9.64a	156.4b	0.846b
Test 2					
Seed-cotton treatments [x]					
Narrow, flat	2.43	2.92	8.00	167.9	0.872
Narrow, chisel	2.44	2.92	7.97	167.8	0.872
Wide, chisel	2.43	2.91	8.17	166.8	0.868
Lint cleaner treatments [y]					
Narrow, chisel	2.43	2.92	8.09	167.6	0.871
SLC	2.44	2.93	8.02	167.0	0.870
Wide, chisel	2.43	2.92	8.07	168.0	0.872
Cultivar					
STV4892	2.47	2.93	6.95b	178.3a	0.892a
DPL555	2.40	2.91	9.15a	156.8b	0.850b

[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 difference (LSD) calculated at appropriate degrees of freedom and p= 0.05 level.

[y] Lint cleaner treatments: Narrow, chisel = a cylinder cleaner with narrowly spaced chisel-shape grid bars followed by a special saw-type lint cleaner with one cleaning point. SLC = saw-type lint cleaner. Wide, chisel = a cylinder cleaner with widely spaced chisel-shape grid bars followed by a special saw-type lint cleaner with one cleaning point.

[x] Seed-cotton treatments: Narrow, flat = a cylinder cleaner with narrowly spaced flat-square grid bars. Narrow, chisel = a cylinder cleaner with narrowly spaced chisel-shape grid bars. Wide, chisel = a cylinder cleaner with widely spaced chisel-shape grid bars.

Table 5. Means of AFIS properties with interaction. [Z]

Source of variance Interaction[y]	Seed-coat neps/g
Test 1	None
Test 2	
Narrow, chisel*DPL555	9.4b
SLC*DPL555	9.8ab
Wide chisel*DPL555	12.2a
Narrow, chisel*STV4892	16.7a
SLC*STV4892	13.8b
Wide, chisel*STV4892	14.6ab

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

[y] Narrow, chisel = a cylinder cleaner with narrowly spaced chisel-shape grid bars followed by a special saw-type lint cleaner with one cleaning point. SLC = saw-type lint cleaner. Wide, chisel = a cylinder cleaner with narrowly spaced chisel-shape grid bars followed by a special saw-type lint cleaner with one cleaning point.

Seed-cotton cleaning performance; Step 1 of Test 2 was specifically designed to evaluate the seed-cotton cleaning performance of the chisel-shape grid bars. Fiber strength was the sole HVI property significantly affected by the seed-cotton cleaner treatments. Fiber strength (Table 1) produced by the chisel-shape grid bars (regardless of spacings) was the strongest. Among AFIS properties (Tables 3-5), neps were the sole property affected; the cylinder cleaner with widely spaced chisel-shape grid bars produced the most neps (mean), although the correspondent nep ratios were not significantly different. This result was counter intuitive, since the cradle with widely spaced grid bars contained fewer grid bars (cleaning points), thus it was expected that it would generate fewer neps during seed-cotton cleaning. However, results seemed to suggest that more cleaning points (narrowly spaced grid bars) might actually produce fewer neps. From the analysis of fiber properties, the seed-cotton cleaning procedure did not seem to affect other fiber properties except neps discussed above. There was no significant interaction effect between seed cotton and lint cleaner treatments on fiber properties.

Table 6 presents comparisons in trash levels in the seed cotton samples after treatments. The treatments did not make a difference in screening out hulls and pin trash. The chisel-shape grid bars in either narrow or wide spacings were more efficient in screening out small leaves and motes. The widely spaced chisel-shape cylinder cleaner was better in filtering out sticks and stems than both narrowly spaced chisel-shape and flat-square cylinder cleaners.

Seed-cotton cleaning efficiency was calculated based on measurements from samples collected before and after the seed-cotton cleaner treatments using the pneumatic fractionation method. Table 7 shows that the seed-cotton cleaner equipped with widely spaced chisel-shape grid bars had the highest seed-cotton cleaning efficiency followed by the narrowly spaced chisel-shape grid bars and lastly, the narrowly spaced flat-square grid bars. These results affirmed that sharper grid bars cleaned seed cotton more efficiently.

Lint turnout, waste, and cleaning efficiency: Results for turnout (Table 7) show that turnout from both cylinder cleaners with narrowly or widely spaced chisel-shape grid bars was significantly higher than that from the SLC. Results from both tests indicated a potential gain of 3.5 kg to 6.3 kg (7.8 lb to 13.8 lb based on 1500 lb of seed cotton) of fiber per bale.

Since waste was negatively correlated to turnout, test results showed that waste produced by the lint cleaner treatment, SLC, was the highest. Furthermore, by processing the waste through a Shirley Analyzer, fiber in the waste generated by the SLC (Table 8) was twice the amount produced by the cylinder cleaners. Thus, although both cylinder cleaners cleaned lint less efficiently, their lower lint cleaning efficiency did not compromise their reflectance, classer's grade and other fiber properties, because they lost more trash to waste proportionally. Specifically, lint cleaning efficiency (Table 7) of the SLC ranged from 47.3% (Test 1) to 52.5% (Test 2). Lint cleaning efficiencies of both cylinder cleaners were significantly lower. They ranged from 27.8% to 34.3% for the respective widely and narrowly spaced chisel-shape grid bars.

Table 6. Means comparisons of trash after the seed cotton treatments. [z]

Source of variance	Small leaf, g	Hulls, g	Motes, g	Sticks and stems, g	Pin trash, g
Test 2					
Seed-cotton treatments [y]					
Narrow, flat	**0.94a**	**2.47**	**3.32a**	**0.74a**	**0.14**
Narrow, chisel	**0.78b**	**2.43**	**3.05b**	**0.73a**	**0.12**
Wide, chisel	**0.74b**	**2.24**	**2.89b**	**0.47b**	**0.12**
Cultivar					
STV4892	**0.82**	**2.86a**	**2.90b**	**0.44b**	**0.15a**
DPL555	**0.81**	**1.89b**	**3.26a**	**0.86a**	**0.10b**

[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 difference (LSD) calculated at appropriate degrees of freedom and p= 0.05 level.

[y] Narrow, flat = a cylinder cleaner with narrowly spaced flat-square grid bars. Narrow, chisel = a cylinder cleaner with narrowly spaced chisel-shape grid bars. Wide, chisel = a cylinder cleaner with widely spaced chisel-shape grid bars.

Since SLC lost the most fiber to waste, wasted fiber should be considered in the nep generation calculation. The total number of neps generated by a cleaner included neps contained in the bale and neps in the wasted fiber. By assuming the same nep density (neps/g) for fiber in the bale and waste, the total number of neps generated could be calculated from nep density, turnout (from 618.8 kg of seed cotton), waste per bale, and wasted fiber. Total neps generated showed unequivocally that both cylinder cleaners with the chisel-shape grid bars generated more neps and SLC generated fewer neps.

Cultivar effects: In seed-cotton cleaning when compared to the hairy-leaf cultivar, the smooth-leaf cultivar had lower levels of hulls and pin trash, and higher levels of motes, and sticks and stems (Table 6). In lint cleaning, the smooth-leaf cultivar had significantly higher strength, reflectance (Table 2), neps and short fiber content (Tables 3-5). Its fiber yellowness, seed-coat neps, fiber length, upper quartile length, fineness, and maturity ratio were significantly lower. The smooth-leaf cultivar had significantly higher turnout, lint cleaning efficiency and cleaned lint in waste (Tables 7 and 8).

Table 7. Summary of lint cleaner and waste performance parameters. [z]

Source of variance	Lint turnout, %	Cleaner waste, kg/bale	Total neps in a bale[w] ($x10^6$ counts)	Cleaning efficiency, % Based on visible waste (Shirley Analyzer)
Test 1				
Lint cleaner treatments [y]				
Narrow, chisel	38.26a	3.53b	75.7a	34.29b
SLC	37.48b	7.97a	67.7b	47.30a
Wide, chisel	38.00ab	3.27b	71.6a	30.84b
Cultivar				
STV4892	37.67b	4.34b	-	37.05
DPL555	38.17a	5.51a	-	37.94
Test 2				
Seed-cotton treatments [x]				
Narrow, flat	39.57	4.65	67.5	9.80c[v]
Narrow, chisel	39.59	4.69	68.9	18.9b
Wide, chisel	39.65	4.59	71.4	26.8a
Lint cleaner treatments [y]				
Narrow, chisel	39.95a	3.16b	71.1a	28.69b
SLC	39.03b	7.59a	66.0b	52.52a
Wide, chisel	39.83a	3.19b	71.5a	27.84b
Cultivar				
STV4892	39.46	4.56	-	34.81b
DPL555	39.75	4.73	-	37.89a

[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 difference (LSD) calculated at appropriate degrees of freedom and p= 0.05 level.

[y] Lint cleaner treatments: Narrow, chisel = a cylinder cleaner with narrowly spaced chisel-shape grid bars followed by a special saw-type lint cleaner with one cleaning point. SLC = saw-type lint cleaner. Wide, chisel = a cylinder cleaner with widely spaced chisel-shape grid bars followed by a special saw-type lint cleaner with one cleaning point.

[x] Seed-cotton treatments: Narrow, flat = a cylinder cleaner with narrowly spaced flat-square grid bars. Narrow, chisel = a cylinder cleaner with narrowly spaced chisel-shape grid bars. Wide, chisel = a cylinder cleaner with widely spaced chisel-shape grid bars.

[w] seed-cotton cleaning efficiency was calculated based on measurements from the pneumatic fractionation method.

[v] Total neps = neps/ g x 1000 x (681.8 x turnout + cleaner waste x lint in waste) (from tables 3, 7 and 8, respectively).

Table 8. Summary for the fiber content in cleaner waste as processed by Shirley Analyzer. [z]

	Cleaned lint in waste, %	Visible waste in waste, %
Test 1		
Lint cleaner treatments[y]		
Narrow, chisel	21.3c	75.9a
SLC	47.6a	51.1c
Wide, chisel	27.3b	70.6b
Cultivar		
STV4892	31.0b	67.0a
DPL555	33.1a	64.8b
Test 2		
Seed-cotton treatments [x]		
Narrow, flat	31.3	67.2
Narrow, chisel	31.0	63.2
Wide, chisel	32.1	65.7
Lint cleaner treatments [y]		
Narrow, chisel	22.3b	74.9a
SLC	44.4a	54.1c
Wide, chisel	27.7b	67.1b

[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 difference (LSD) calculated at appropriate degrees of freedom and p= 0.05 level.

[y] Lint cleaner treatments: Narrow, chisel = a cylinder cleaner with narrowly spaced chisel-shape grid bars followed by a special saw-type lint cleaner with one cleaning point. SLC = saw-type lint cleaner. Wide, chisel = a cylinder cleaner with widely spaced chisel-shape grid bars followed by a special saw-type lint cleaner with one cleaning point.

[x] Seed-cotton treatments: Narrow, flat = a cylinder cleaner with narrowly spaced flat-square grid bars. Narrow, chisel = a cylinder cleaner with narrowly spaced chisel-shape grid bars. Wide, chisel = a cylinder cleaner with widely spaced chisel-shape grid bars.

SUMMARY AND CONCLUSION

The objective of the experiments was to evaluate the effectiveness of the newly designed chisel-shape grid bars in cleaning seed cotton (Test 2) and ginned lint (Test 1 and Test 2). Overall, the two cylinder cleaners with narrowly and widely spaced chisel-shape grid bars performed very similarly in terms of fiber properties, turnout, and lint cleaning efficiency. Though when compared to a standard SLC, these cylinder cleaners cleaned lint less efficiently. They provided higher turnout, and could potentially gain a maximum of 6.4 kg/bale (14.3 lb/bale) of fiber, because they lost less than half of the fiber lost by the SLC and contained proportionally more trash in their waste. As a result, these cylinder cleaners achieved higher turnout without degrading the color properties in reflectance and yellowness. Most fiber properties were not affected by the cylinder cleaners except neps, seed-coat neps and lint cleaning efficiency. Both cylinder cleaners generated more neps in the bale. There was no significant interaction between seed-cotton and lint cleaning treatments on fiber properties and other performance measures. Finally, both cylinder cleaners with narrowly or widely spaced chisel-shape grid bars achieved the higher turnout; the narrow gap configuration used six cylinders and the wide gap configuration used only three. When compared to the flat-square grid bars, the seed–cotton cleaning efficiency of the chisel-shape grid bars was higher due to its sharp beveled edges.

In comparison to the hairy-leaf cultivar, the smooth-leaf cultivar had higher fiber strength, reflectance, neps and short fiber content. It produced lower seed-coat neps, fiber length, fineness and maturity ratio. Lint of the smooth-leaf cultivar was generally easier to clean as shown by its low VFM. Its leaf-grade property was generally lower and unlike the hairy-leaf cultivar, the smooth-leaf cultivar was not sensitive to lint cleaner treatments.

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 recommendation of the product to the exclusion of others that may be suitable.

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