INVESTIGATION OF METHODS TO IMPROVE THE EFFICIENCY OF AN EXPERIMENTAL COTTON GIN

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ABSTRACT

Lint cotton removed by an experimental ginning process was evaluated to determine if varying nip roll pressures affected removal rates and fiber quality. An experiment was also performed to determine if air deflectors used to re-orient the seed cotton affected ginning performance. Tests showed that increasing nip roll pressure increases lint removal rates and did not affect the quality of the fiber. The installation of the air deflectors did not affect lint removal rates or fiber quality.

ACKNOWLEDGEMENT

I would like personally to thank Mr. Lambert Wilkes and Mr. Kenneth Watkins for their leadership and guidance throughout this project. It has been both an honor and a privilege to work with one of the leading figures in cotton research, Mr. Lambert H. Wilkes. Thanks also go to the Honors Program for providing a chance for undergraduates to participate in research.

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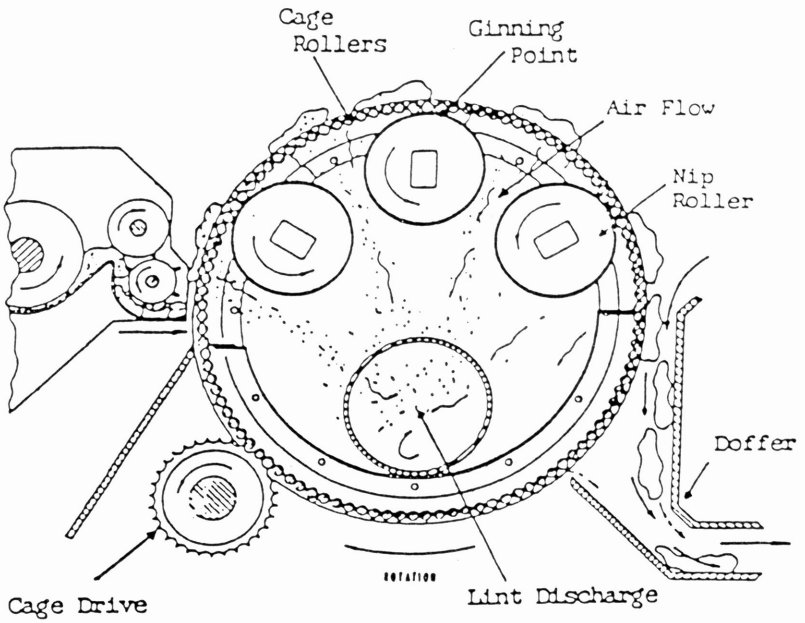
INTRODUCTION

The seed cotton that is produced and harvested must be processed in order to remove the lint fiber from the seed. The conventional method of removing the lint from the seed is referred to as saw ginning. This is the most common method of processing. It employs a set of saws and ribs. Seed cotton is fed into the gin, where it forms a seed roll. The lint fiber is then pulled from the seed cotton by the teeth of the saws.

A new type of ginning has been developed in a cooperative project between COTTON INCORPORATED and the Agricultural Engineering Department of the Texas Agricultural Experiment Station (Wilkes, et al. 1984). This method is referred to as selective ginning. The original intent of this process was to selectively remove the longer fibers from the seed cotton without removing the shorter fibers. The objective of this project has recently been modified to explore the possibilities of removal of all of the lint with the new process.

A drawing that illustrates the basic configuration and parts of the gin is shown in Figure 1. The gin consists of a series of 3/4 inch rollers mounted on a circular cage that rotates. Each individual roller in the cage is free to rotate. The seed cotton is held onto the cage by an inward airflow to the center of the



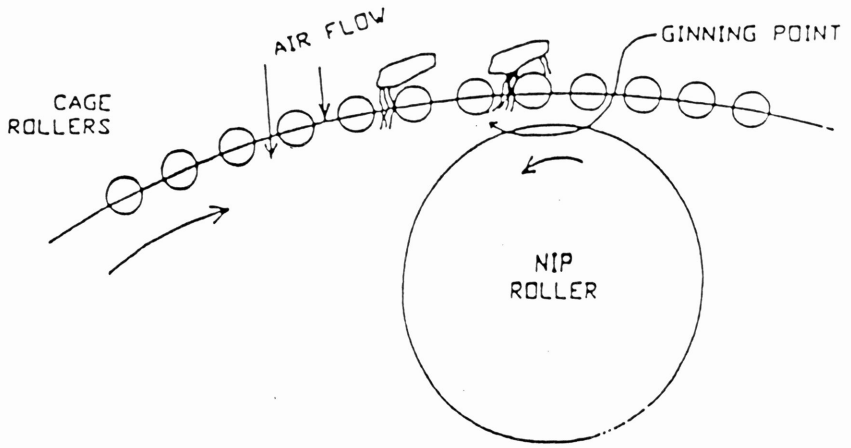


FIGURE 1. THE SELECTIVE GIN

cage. The spacing between the cage rollers is large enough for lint to pass through, but small enough to prevent seed from being drawn into the cage. Inside the cage are rubber covered rollers, called nip rollers, which are held against the inside of the cage rollers. The cage is driven in one direction and the nip rollers are driven in the opposite direction. This produces a pinching action at each point of contact between the nip rollers and the cage rollers. Each of these points is a ginning point where the lint fiber is actually removed from the seed. The amount of lint removed can be changed by varying the air pressure, the pressure by the nip rolls against the cage rollers and the number of ginning points. The lint remaining on the seed after selective ginning is removed by a conventional gin. This process is referred to as residual ginning.

Different nip roll pressures are designated by specific codes. An example would be the 15-15-15 setting. The numbers used are abitrarily assigned to denote differing pressures exerted by the nip rolls against the cage rollers. The first 15 tells the pressure exerted by the first nip roll against the cage rollers. The second 15 represents the pressure exerted by the second nip roll against the cage rollers and the last 15 represents the pressure exerted against the cage rollers by the third nip roll.

Lint removed by the Selective Gin is higher in quality than that which is conventionally ginned. There are several factors that affect fiber quality. These properties are evaluated in two separate tests that are used to determine lint fiber quality. The first is the High Volume Instruments Classification System. The second is the Suter-Webb Fiber Array which is for research purposes only.

The High Volume Instruments Classification System includes fiber length, uniformity, strength, and fineness. Length of fiber or staple length is the length of the fibers measured in inches. This is a principle factor that determines the value of the farmer's crop. Increased length is desirable for finer fabrics. Uniformity refers to the consistency of the length of fibers. Average values for uniformity are from 80 to 82. Strength is a measure of how strong the fibers are. The fineness of the fiber is measured in terms of micronaire which refers to the individual diameter or fineness of the fibers.

The Peyer AL-101 is an instrumented version of the Suter-Webb Fiber Array. The Peyer AL-101 analysis includes mean length, coefficient of variation, short and long fiber contents and upper quartile length. Mean length is the average length of fiber and is measured in inches. The coefficient of variation is closely related to fiber uniformity and is measured by percent variation. A low value for variation is desired. Short fiber

content represents the percent of fiber less than 1/2 inch in length by weight. Upper quartile is the upper 25 percent of the fiber as measured by length in inches. Long fiber is that fiber which is greater than one inch in length and is measured by percent long fiber.

Selective ginning has been evaluated with several varieties of cotton (Wilkes, Watkins, and Lalor, 1985). Lint selectively ginned is generally longer, stronger, and more uniform than lint that is saw ginned. The selective lint has a lower percent short fiber and coefficient of variation. The selectively removed lint has a larger percent long fiber, mean length, and upper quartile length. The residual lint fiber contains a larger percent short fiber than conventionally ginned lint as would be expected.

OBJECTIVE

This research involved the "Investigation of Methods to Improve the Efficiency of an Experimental Cotton Gin." The basic objective of the research was to investigate means of improving the lint removal of the Selective Gin without damaging the fiber that is removed.

PROCEDURE

One variety of cotton (Dunn 1019) grown during the 1985 season on the High Plains of Texas was used in the tests. The cotton was harvested by a stripper and processed through conventional cleaning machines to remove the trash from the seed cotton.

In the first experiment there were a total of 4 nip roll pressure settings evaluated without the air deflectors installed. The nip roll settings were increased in each treatment to determine their effect on lint removal rates. Pressure settings were measured and recorded. Each setting was replicated 3 times to obtain the reliability of the results. The replications of each setting were randomized. Lint removal rates were calculated and averaged. Samples of lint fiber were sent to the Textile Testing Laboratory in Lubbock, Texas, for fiber analysis. These analyses included both the High Volume Instruments Classification System (HVI) and the Peyer AL-101 tests.

The second experiment included evaluation of adding air deflectors to help re-orient the seed cotton on the cage. The reason for this test was to increase the exposure time of the lint to the ginning points. Each nip roll setting was evaluated with the air deflectors installed and 3 randomized replications

of each were conducted to obtain the accuracy of the results. Lint removal rates were calculated and averaged for each test. Samples were also sent to the Textile Testing Laboratory. Both the High Volume Instruments Classification System and the Peyer AL-101 tests were performed to determine if any changes in fiber quality occurred.

All tests were conducted with 10 pound samples of seed cotton. Throughout the testing the amount of time to gin each sample of seed cotton was recorded and the feed rate to the gin was held constant. The relative humidity and temperature were recorded to aid in making moisture determinations. The rotating cage was kept at a constant speed of 150 feet per minute and the nip rolls were kept at a constant speed of 72 revolutions per minute to minimize the variables.

After seed cotton had been selectively ginned the lint remaining on the seed was removed by a conventional saw gin. This fraction of the lint is referred to as residual lint. Samples of the residual lint were also sent to the Textile Testing Laboratory for analyses of the fiber properties.

All data collected were subjected to statistical analysis. The Duncan MultiRange Variance test with a 95 percent confidence level was used.

RESULTS

Effects that nip roll pressures have on lint removal rates without air deflectors are shown in Table 1. The 15-15-15 setting represents the highest nip roll pressure exerted against the cage rollers. The 5-10-15 represents the least nip roll pressure used in the tests. The 15-15-15 setting achieved the highest lint removal rate, but due to the physical limitations of the experimental gin this setting could not be maintained for extended periods of time. The 15-10-15 setting results in the highest lint removal rate that can be achieved with smooth operation of the gin. There is also clearly a direct relationship between increasing nip roll pressures and the amount of lint removed. The different letters after each removal rate indicate a statistical significant difference between the settings. This system will be used throughout the tables to indicate significant differences in the values shown.

The effects that increasing nip roll pressures have on fiber properties evaluated by the High Volume Instruments Classification System are shown in Table 2. When analyzed, the properties of length, uniformity, and strength indicated no significant difference among removal rates. The fineness of the lint fiber is affected slightly by different removal rates, but

the 15-10-15 setting maintains a reasonably high value for micronaire.

Results of the Peyer AL-101 tests are presented in Table 3. The only property that shows any significant differences is the coefficient of variation. This difference is desirable, because the 15-10-15 setting has one of the lowest values, which is desirable.

The lint removal rates for the residual saw ginned lint are shown in Table 4. The residual lint removal rates represent the difference between the Selective Gin removal rates and 100 percent ginning.

Effects that increasing the nip roll settings has on fiber properties as measured by the High Volume Instruments Classification System and Peyer AL-101 analyses are shown in Tables 5 and 6. No statistically significant differences were detected in either evaluation.

The data presenting the effects that increasing nip roll pressures have on removal rates, with the air deflectors installed, is shown in Table 7. As in the tests without air deflectors, the physical limitations of the Selective Gin prevent it from being able to maintain desired speeds at the 15-15-15 setting.

Information on the lint fiber properties with the air deflectors installed is shown in Tables 8 and 9. Statistically, significant differences are indicated in uniformity, fineness, mean length, coefficient of variation, and percent short fiber. Both the data from the High Volume Instruments Classification System and the Peyer AL-101 consistently point out that the 10-10-15 setting is best where quality is concerned. These results differ from those obtained from the data with the deflectors removed.

The removal rates for the residually ginned lint with the air deflectors installed are shown in Table 10.

Effects that increasing the nip roll settings have on fiber properties as measured by the High Volume Instruments Classification System and Peyer AL-101 analyses are shown in Tables 11 and 12. No statistically significant differences were detected in either evaluation.

The data comparing lint removal rates of the Selective Gin with and without the air deflectors is presented in Table 13. This data is only for the 15-10-15 nip roll setting. This setting has the highest removal rates without causing problems with the machinery. At this setting, the deflectors show a slight advantage over the removal rates without the deflectors. This is

a numerical difference and no statistical difference was detected.

Analyses of the data obtained from the High Volume Instruments Classifications System and the Peyer AL-101 tests for evaluating fiber quality are in Tables 14 and 15. Fineness is the only property that indicates any statistical difference. The micronaire with the air deflectors is slightly higher than the that without the deflectors.

Removal rates for the residually ginned lint with and without the air deflectors installed are shown in Table 16. No significant differences are revealed by this data.

The effects of the deflectors on the fiber properties analyzed by the High Volume Instruments Classifications are shown in Table 17. This data showed no significant differences.

The Peyer AL-101 analysis is presented in Table 18. There is statistical significance in the properties of mean length, coefficient of variation, and percent short fiber. These differences do not clearly point to an answer, because a final determination would be dependent on the importance of each property in each particular situation.

SUMMARY

This research has been to determine if it is possible to remove all of the lint with the new process thereby replacing the present saw ginning process.

This research has shown that it is possible to increase the percentage of lint removed to 75 percent by increasing both the number of nip rolls and the nip roll pressure. Previous research with this experimental gin has been directed towards removing only about 40 to 50 percent in an effort to remove only the longer fibers. This process was successful in improving the quality of the lint removed. The system would however entail the use of additional and duplicate equipment in the gin which may retard the acceptance of the new process.

The air deflectors used in this research had no apparent effect on the lint removal efficiency. A very encouraging aspect of the higher lint removal rates is that the fiber properties were not affected as would be expected with the higher removal rates.

From these tests, it appears that the 75 percent removal rate is about the maximum attainable with this present experimental machine. Other aspects that should be investigated are air flow patterns and a flat design.

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Table 1. Effects of nip roll pressure on removal rates of selectively ginned lint WITHOUT deflectors. 1986.

Nip Roll Settings	15-15-15 / 15-10-15 / 10-10-15 / 5-10-15			
Treatment Number	1	2	3	4
Removal Rates (%)	75.55 a	67.38 b	60.51 c	47.77 d

Table 2. Effects of nip roll pressure on fiber properties of selectively ginned lint WITHOUT deflectors as measured by the High Volume Instruments Classing System. 1986.

Removal Rate(%)	
	Length (inches)
75.55	1.063 a
67.38	1.066 a
60.51	1.080 a
47.77	1.083 a
	Uniformity Ratio
75.55	82.0 a
67.38	81.0 a
60.51	81.3 a
47.77	80.7 a
	Strength (gm/tex)
75.55	27.7 a
67.38	26.7 a
60.51	27.3 a
47.77	27.0 a
	Fineness (Micronaire)
75.55	3.40 a
67.38	3.36 ab
60.51	3.43 a
47.77	3.23 b

Table 3. Effects of nip roll pressure on fiber properties of selectively ginned lint WITHOUT deflectors as measured by the Peyer AL-101 analysis. 1986.

Removal Rate(%)	
	Mean Length (inches)
75.55	0.83 a
67.38	0.85 a
60.51	0.85 a
47.77	0.84 a
	Coefficient of Variation
75.55	36.8 ab
67.38	35.7 b
60.51	35.6 b
47.77	37.9 a
	Short Fiber (percent)
75.55	18.8 a
67.38	16.8 a
60.51	16.8 a
47.77	19.3 a
	Upper Quartile
75.55	1.07 a
67.38	1.08 a
60.51	1.07 a
47.77	1.08 a
	Long Fiber (percent)
75.55	34.0 a
67.38	36.0 a
60.51	34.8 a
47.77	35.1 a

Table 4. The percent of fiber removed by residual ginning after selective ginning WITHOUT deflectors. 1986.

	Nip Roll Settings			
	15-15-15 / 15-10-15 / 10-10-15 / 5-10-15			
Treatment Number	1	2	3	4
Removal Rates (%)	24.45 c	32.62 c	39.49 b	52.23 a

Table 5. Properties of residual lint removed after selective ginning WITHOUT deflectors as measured by the High Volume Instruments Classing System. 1986.

Removal Rate(%)	
	Length (inches)
24.45	1.013 a
32.62	1.040 a
39.49	1.027 a
52.23	1.023 a
	Uniformity Ratio
24.45	79.7 a
32.62	79.7 a
39.49	79.3 a
52.23	80.0 a
	Strength (gm/tex)
24.45	25.7 a
32.62	26.3 a
39.49	25.0 a
52.23	25.3 a
	Fineness (Micronaire)
24.45	3.66 a
32.62	3.73 a
39.49	3.70 a
52.23	3.80 a

Table 6. Properties of residual lint after selective ginning WITHOUT deflectors as measured by the Peyer AL-101 analysis. 1986.

Removal Rate(%)	
	Mean Length (inches)
24.45	0.74 a
32.62	0.71 a
39.49	0.75 a
52.23	0.74 a
	Coefficient of Variation
24.45	40.9 a
32.62	41.4 a
39.49	40.2 a
52.23	39.7 a
	Short Fiber (percent)
24.45	27.4 a
32.62	29.7 a
39.49	26.4 a
52.23	26.3 a
	Upper Quartile
24.45	0.98 a
32.62	0.94 a
39.49	0.99 a
52.23	0.98 a
	Long Fiber (percent)
24.45	23.0 a
32.62	19.2 a
39.49	24.1 a
52.23	23.1 a

Table 7. Effects of nip roll pressure on removal rates of Selective Gin WITH deflectors. 1986.

	Nip Roll Settings 15-15-15 / 15-10-15 / 10-10-15 / 5-10-15			
Treatment Number	1	2	3	4
Removal Rates (%)	74.75 a	70.35 a	61.25 b	47.05 c

Table 8. Effects of nip roll pressure on fiber properties of selectively ginned lint WITH deflectors as measured by the High Volume Instruments Classing System. 1986.

Removal Rate(%)	
	Length (inches)
74.75	1.063 a
70.35	1.057 a
61.25	1.077 a
47.05	1.070 a
	Uniformity Ratio
74.75	80.7 b
70.35	81.3 ab
61.25	81.7 a
47.05	81.0 ab
	Strength (gm/tex)
74.75	27.0 a
70.35	26.7 a
61.25	26.3 a
47.05	26.3 a
	Fineness (Micronaire)
74.75	3.50 a
70.35	3.47 ab
61.25	3.43 ab
47.05	3.33 b

Table 9. Effects that nip roll pressures have on the fiber properties of selectively ginned lint WITH deflectors as measured by the Peyer AL-101 analysis. 1986.

Removal Rate(%)	
	Mean Length (inches)
74.75	0.84 ab
70.35	0.83 ab
61.25	0.86 a
47.05	0.81 b
	Coefficient of Variation
74.75	36.7 a
70.35	36.0 ab
61.25	34.7 b
47.05	37.2 a
	Short Fiber (percent)
74.75	18.3 ab
70.35	17.7 ab
61.25	15.7 b
47.05	19.5 a
	Upper Quartile
74.75	1.08 a
70.35	1.07 a
61.25	1.08 a
47.05	1.06 a
	Long Fiber (percent)
74.75	35.0 a
70.35	33.7 a
61.25	35.9 a
47.05	31.7 a

Table 10. Effects that nip roll pressures have on residual lint removal rates after selective ginning WITH deflectors. 1986.

	Nip Roll Settings			
	15-15-15 / 15-10-15 / 10-10-15 / 5-10-15			
Treatment Number	1	2	3	4
Removal Rates (%)	25.25 c	29.65 c	38.75 b	50.95 a

Table 11. Effects that nip roll pressures have on fiber properties of residually ginned lint after selective ginning WITH deflectors as measured by the High Volume Instruments Classing System. 1986.

Removal Rate(%)	
	Length (inches)
25.25	1.013 a
29.65	1.010 a
38.75	1.030 a
50.95	1.023 a
	Uniformity Ratio
25.25	80.0 a
29.65	79.3 a
38.75	79.7 a
50.95	79.0 a
	Strength (gm/tex)
25.25	26.0 a
29.65	25.0 a
38.75	24.7 a
50.95	25.3 a
	Fineness (Micronaire)
25.25	3.70 a
29.65	3.80 a
38.75	3.90 a
50.95	3.80 a

Table 12. Effects that nip roll pressures have on fiber properties of residually ginned lint after selective ginning WITH deflectors as measured by the Peyer AL-101 analysis. 1986.

Removal Rate(%)	
	Mean Length (inches)
25.25	0.77 a
29.65	0.75 a
38.75	0.74 a
50.95	0.76 a
	Coefficient of Variation
25.25	38.2 a
29.65	38.9 a
38.75	38.6 a
50.95	39.1 a
	Short Fiber (percent)
25.25	23.5 a
29.65	25.5 a
38.75	24.8 a
50.95	24.1 a
	Upper Quartile
25.25	1.00 a
29.65	0.98 a
38.75	0.97 a
50.95	1.00 a
	Long Fiber (percent)
25.25	25.3 a
29.65	22.5 a
38.75	21.7 a
50.95	24.9 a

Table 13. Effects that DEFLECTORS have on Selective Gin removal rates. 1986.

	Without Deflectors	With Deflectors
Removal Rates (%)	62.80 a	63.85 a

Table 14. Effects that DEFLECTORS have on fiber properties of selectively ginned lint as measured by the High Volume Instruments Classing System. 1986.

Removal Rate(%)	
	Length (inches)
62.80	1.070 a
63.85	1.070 a
	Uniformity Ratio
62.80	81.2 a
63.85	81.0 a
	Strength (gm/tex)
62.80	27.0 a
63.85	26.0 a
	Fineness (Micronaire)
62.80	3.36 b
63.85	3.43 a

Table 15. Effects that DEFLECTORS have on fiber properties of selectively ginned lint as measured by the Peyer AL-101 analysis. 1986.

Removal Rate(%)	
	Mean Length (inches)
62.80	0.84 a
63.85	0.84 a
	Coefficient of Variation
62.80	36.5 a
63.85	36.1 a
	Short Fiber (percent)
62.80	17.9 a
63.85	17.8 a
	Upper Quartile
62.80	1.08 a
63.85	1.07 a
	Long Fiber (percent)
62.80	35.0 a
63.85	34.1 a

Table 16. Effects that DEFLECTORS have on residually ginned lint removal rates after selective ginning. 1986.

	Without Deflectors	With Deflectors
Removal Rates (%)	37.20 a	36.15 a

Table 17. Effects that DEFLECTORS have on fiber properties of residual lint after selective ginning as measured by the High Volume Instruments Classing System. 1986.

Removal Rate(%)	
	Length (inches)
37.20	1.026 a
36.15	1.019 a
	Uniformity Ratio
37.20	80.0 a
36.15	79.0 a
	Strength (gm/tex)
37.20	26.0 a
36.15	25.0 a
	Fineness (Micronaire)
37.20	3.73 a
36.15	3.80 a

Table 18. Effects that DEFLECTORS have on fiber properties of residual lint after selective ginning as measured by the Peyer AL-101 analysis. 1986.

Removal Rate(%)	
	Mean Length (inches)
37.20	0.74 b
36.15	0.76 a
	Coefficient of Variation
37.20	40.6 a
36.15	38.7 b
	Short Fiber (percent)
37.20	27.5 a
36.15	24.5 b
	Upper Quartile
37.20	0.97 a
36.15	0.99 a
	Long Fiber (percent)
37.20	22.3 a
36.15	23.6 a