EVALUATION OF POWERED ROLL GIN STAND FOR SEED COTTON

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Abstract

Research at the USDA-ARS ginning laboratory at Lubbock, Texas developed a new saw gin stand with a powered paddle roll turning the seed roll and rotating seed fingers regulating seed discharge. This gin produced up to 2.2 percent points higher turnout from the seed cotton compared to a modern high capacity gin stand. This yields approximately 7 percent more lint (35 pounds per bale) from the seed cotton. Fiber quality data from several tests shows the experimental gin produces slightly better staple length. The new gin stand has higher production rates per unit width and uses less power for ginning. Higher turnout and better fiber length will substantially benefit cotton producers. A cooperative research and development program has been initiated to investigate a number of gin stand design factors that were found to affect gin performance and cotton yield and quality. A patent was obtained through the USDA-ARS patent division for the paddle roll gin stand (U. S. Patent number 6,061,875).

Introduction

The powered roll gin stand was originally developed to remove residual fibers that caused problems for the EASI*flo*™ process which makes fuzzy cottonseed free flowing (Laird, Wedegaertner and Valco. 1997). Cottonseed from conventional gin stands contains long fiber that must be removed to avoid excessive buildup on mixing machinery used in the EASI*flo*™ cottonseed coating process. Normally cottonseed cannot be ginned a second time because the seed roll in the gin stand will not turn unless unginned cotton is fed in underneath the seed roll through the huller front. Fiber quality measurements showed that the properties of lint from reginning seeds was comparable to the lint from the original ginning process (Laird and Wedegaertner. 1999). The amount of fiber removed from the reginned seeds averaged about 2.5 percent of the seed weight. This amounts to 4 to 5 percent of additional lint if it had been put into the bale. The research was expanded to evaluate the powered roll gin stand technology as the primary ginning device capable of getting all of the long lint into the bale. The gin stand technology development effort was successful and a patent has been obtained through the USDA-ARS patent division to cover the paddle roll gin stand (Laird. 2000) (U. S. Patent number 6,061,875).

The research tests revealed a number of factors related to gin stand design and operation that can have significant effects on gin stand performance and lint turnout and fiber quality. A basic research program has been initiated at the USDA-ARS ginning laboratory at Lubbock, TX to investigate these factors. A cooperative Research and Development Agreement, CRADA, has been formed between USDA-ARS, Cotton Incorporated, American Industrial and Bearing Co., and J & F Saw and Gin Machinery Inc., to carry out the research and development effort.

Equipment

The experimental gin stand was constructed by modifying an older model 90 saw gin stand with 12-inch saws. The paddle roll provided by CRADA partner American Industrial and Bearing Supply had four rubber strip paddles mounted on a 2.5-inch schedule 80 pipe core giving an 8.5-inch tip diameter. The powered paddle roll was installed in the center of the roll box to turn the seed roll and driven by a separate motor installed at the left end of the gin stand, Figure 1. Conventional roll agitators and rotating seed tubes were evaluated but would not reliably turn the seed roll without having seed cotton fed in at the bottom through a huller font. The gin stand was modified by CRADA partner J & F Saw by making new rib rails and replacing the original ribs with narrower ribs to get a closer 5/8 -inch saw spacing. The saw spacers were trimmed to fit the narrow rib spacing and 110 saws were installed on the original saw mandrel. The original roll box on the gin stand was a flattened oval shape. The upper back section of the roll box was pivoted up and back about 1 inch at the top to give a round shape to match the paddle roll. A new front was constructed for the gin roll box to replace the conventional huller front. A power driven rotating seed finger mechanism was developed that pushes the cotton into the gin saws to increase contact and capture of the lint by the saw, Figure 2. The rotating seed finger also helps to control the rate that seeds discharge from the gin stand. The new front roll box shape was designed to expose more area of the saw within the roll box where it contacts the cotton. The gin stand, as tested, had an 8-1/2 inch diameter paddle roll running about 160 rpm and 4-1/2 inch overall diameter rotating seed fingers with a variable speed drive operated at 5 to 15 rpm.

Procedure

A preliminary evaluation of the new gin stand technology on seed cotton was carried out to measure ginning performance and lint properties. Initially a bulk feeder hopper that is used to feed cottonseed to the gin stand for reginning was used to drop seed cotton into the gin stand at the desired rate. After the first ginning test showed promising results, the bulk feeder was replaced with a used, conventional Continental Comet model gin stand feeder. A series of ginning tests are underway and the current data is included in this report.

We found that the power load on the paddle roll was the best control signal for feed rate, and ginning rate was very responsive to paddle roll loading. Ginning rate increased with gin saw speed. The effect of the speed of the seed fingers is less clear although it relates to the level of cleaning of the seeds. The gin feeder was controlled by a Comtrex DC drive sensing the amp load from the paddle roll drive motor to maintain a given loading on the paddle roll motor. In early trials the paddle roll was driven with a 7.5 horsepower motor connected to an inverter drive for speed control. This was later replaced with a 15 horsepower drive. The gin saw was originally driven with a 15 horsepower motor which was replaced with a 60 horsepower motor as ginning trials showed that horsepower was directly related to ginning rate and more was needed.

The ginning tests compared the experimental 110 saw powered roll gin stand with the conventional Continental Double Eagle 93 saw gin stand in the laboratory gin plant as the control. The cotton used for the tests was uniform lots of machine-stripped cotton. There were differences between lots and many of the lots had been field cleaned. All of the lint was run through one or two saw type lint cleaners which were in a battery lint cleaner configuration so that the same lint cleaner(s) was used for both the experimental and conventional gin stands.

The equipment and procedure for all the tests was comparable. The Continental Comet feeder used for the experimental gin stand is a stick machine type gin stand feeder very similar to the later model Challenger feeder on the conventional gin stand. The test lots were fed from the feed control bin at a constant rate through an inclined cleaner and stick machine, a second incline cleaner and stick machine, and to the conveyor distributor over the gin stands. The double overhead cleaning system was not always necessary but was used to reduce the amount of trash in the cotton reaching the gin stand feeder to minimize the difference in treatments due to different gin stand feeders.

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 2:1377-1380 (2001)
National Cotton Council, Memphis TN

Results

Previous Work

Two ginning tests were conducted with the 7.5 horsepower motor on the paddle roll and the 15 horsepower motor driving the gin saw. The results from these tests was reported in a paper given in July 2000 at the ASAE International Annual Meeting (Laird, Holt, and Wedegaertner, 2000) . The experimental gin stand gave 1.7 and 1.4 points higher lint turnout in these tests compared to the conventional gin stand. The higher lint turnout produced approximately 5.1 percent more lint or 25.5 more pounds in the bale from the same amount of seed cotton.

High Volume Instrument (HVI grades) showed that classers staple, HVI length and brightness (Rd) for lint from the experimental gin was slightly increased compared to lint ginned with the conventional gin. Fiber length after one lint cleaner averaged one-half staple length higher for the experimental gin stand. The results from these tests is given in detail in the ASAE paper. The ginning rate in these tests was about 2.3 bales per hour for the experimental gin stand compared to 5.1 bales per hour for the conventional gin. The ginning tests showed that the gin stand was capable of much higher ginning rates but that more power was needed for both the gin saw and paddle roll.

Current Progress

One test using cotton from two sources examined the effect of paddle roll amps on ginning rate, turnout and fiber quality. This test was done before changing out the 7.5 horsepower motor on the powered roll drive. We used two cotton lots, one from the 1999 crop and one from the 2000 crop. Ginning treatments were the experimental gin with the feeder control set for two levels (8 and 11 amps) on the paddle roll drive and the other treatment was the conventional gin stand with the feeder control at 75 % amp load on the gin saw motor. The 12-inch saw in the experimental gin was operated at 840 rpm to give the equivalent saw tip speed as the 16-inch saw in the conventional gin turning at 630 rpm.

Operating results for this trial showed that ginning rate for the experimental gin varied with paddle roll amp loading. Except for 2000 crop cotton with 11 paddle roll amps, ginning rate was not as high as the conventional gin running at high capacity, Table 1. Power use for the gin saw in kilowatts per bale followed a similar trend as ginning rate for the experimental gin which used less than the conventional gin. Average lint turnout for the experimental gin was 0.4 to 1.9 percent points higher than the conventional gin. Turnout was different for the cotton from different crop years mostly because a field cleaner was used on the harvester for the 2000 crop.

HVI results for lint samples from the test showed that fiber length measurements tended to be better for the cotton ginned in the experimental gin, Table 2. HVI length for cotton from both years was significantly higher and length uniformity was significantly higher for cotton from the 2000 crop. Lint samples from the test were also evaluated on the AFIS (Advanced Fiber Information System) by the International Textile Center at Texas Tech University. The results agreed with the HVI analysis, with the mean length, L(w), length coefficient of variation and short fiber content showing better length for cotton ginned on the experimental gin stand, Table 3. Upper quartile length was not significantly different indicating that the experimental gin tended to preserve fiber length in the middle and short range which may indicate that it does less fiber breakage. The short time for the seed roll in the experimental gin stand to empty out when the feed is cut off indicates that the seeds are cleaned much quicker and there is less opportunity for fiber damage. There were no differences in maturity ratio or immature fiber content, IFC%, indicating that more complete ginning was not removing a different class of fibers from the seeds. There were differences in seed coat neps, dust, trash and AFIS visible foreign matter for the 2000 crop cotton which was fairly high in trash. This could have resulted because of ginning rate difference and varying batt thickness in the saw type lint cleaners.

This test used the maximum output of the 7.5 horsepower paddle roll motor which had a full load rating of 10.7 amps. The highest power load measured on the 60 hp gin saw motor indicated about 45 hp. There was no indication of harm to fiber properties and the gin roll was still very loose so the paddle roll motor was replaced with a 15 hp drive to enable tests at higher ginning rates.

A test was conducted to determine performance of the experimental gin with the gin stand feeder control set for a range of higher paddle roll loadings possible with the larger motor driving the paddle roll. The experimental design for the test used four paddle roll amp loadings in conjunction with three seed finger speeds and three lots of cotton in a random block arrangement. Ginning rate increased directly with paddle roll power load, Table 4. The test showed that the gin stand is capable of relatively high ginning rates. In fact we did not find the maximum ginning rate for the gin stand because it was above the capacity of the 60 horsepower motor running the gin saw. The seed roll was still loose at the highest ginning rate and the gin stand is capable of higher ginning rates with adequate power on the saw shaft. One test run reached 99 horsepower indicated by the kilowatt draw shown on the variable frequency drive for the gin stand motor. Power use per bale of cotton ginned by the experimental gin stand (saw plus paddle roll), indicated by kilowatts per bale, increased with the ginning rate (paddle roll amps) but stayed well below power used by the conventional gin stand.

Just as in the previous tests the experimental gin produced significantly higher turnout from the seed cotton and turnout trended higher with higher ginning rate. The added amount of lint from the seed cotton was substantial for some of the treatments in this test, giving the highest achieved so far, with a mean value of 7.7 percent increase, about 37 pounds per bale, for the lots ginned with 18 amp paddle roll loading. The data seem to indicate that increased turnout will not be lost from higher ginning rates for the experimental gin stand.

Running the seed fingers at a higher speed was expected to increase ginning rate by taking the ginned seeds out of the gin stand faster but the data does not show a clear trend, Table 5. Individual lot data have a wide spread and there is little trend or interaction indicated for the seed finger speed in relation to the other operating parameters. Power use and lint turnout were not significantly affected by seed finger speed. Lint quality data for the higher ginning rate tests is not available yet. The lint samples from before and after two saw type lint cleaners are waiting for evaluation in the backlog at the classing office.

Paddle roll operating speed of 160 rpm was used in the ginning trials based on tests that showed this was the optimum speed when reginning cottonseed. Paddle roll speed, saw speed, and several configuration variables such as shape and placement of the roll box front and seed fingers need more research. The maximum ginning rate possible with a 60 horsepower motor on the gin saw has given no indication of reaching the point where there may be detrimental effects on lint or seed quality. The research effort has encountered several mechanical limits such as power required for the paddle roll or gin saw that have been overcome in stepwise fashion. Currently a limit is the 60 horsepower gin saw motor which is being replaced with a 75 horsepower motor. This will be a mechanical limit for the existing gin stand because of the maximum safe power transmission through the 2-inch diameter shaft of the saw mandrel. There was an indication that with the 20 amp paddle roll loading seed cotton feed rate may be getting too high for the cotton to be pulled down into the seed roll. This can be overcome if necessary by modification of the roll box front and/or adding a rotating element to the top lip. Two additional mechanical limitations for the research setup that may come up are capacity of the

Comet gin stand feeder and paddle roll motor power. A research program is being planned and we are building a research scale gin stand that will have the capability of investigating fully all of the design and operating parameters.

Conclusions

The experimental powered roll gin stand gives significantly higher turnout from the seed cotton and also maintains better fiber length. It is capable of much higher ginning rates per unit width than the conventional saw gin stand. The potential effect of significant differences in fiber properties obtained need to be studied in spinning trials. There are a number of gin stand design factors that require more research but the results from the experimental machine show that a significant benefit for cotton producers and ginners is possible using the new technology.

Note: Specific company or product names are used in this paper for exact information and is not a recommendation or endorsement over other similar products by USDA-ARS. This research is the product of a cooperative research and development agreement between USDA-Agricultural Research Service, American Industrial Bearing and Supply, J & F Saw and Gin Machinery Inc., and Cotton Incorporated.

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Table 1. Ginning rate, power use and turnout for the experimental 110 saw gin stand with the feeder control set for ginning rates that gave 8 and 11 amps load on the powered roll, compared with a modern high capacity Continental Double Eagle 93 saw gin stand using cotton from the 1999 and 2000 crops.

Gin treatment	PR amps	Ginning rate, Bales/hour Cotton 1999	2000	Power use, kW/bale Cotton 1999	2000	Turnout, % Cotton 1999	2000
Exp-110	8	4.3	4.7	4.3	4.9	23.2	29.8
	11	5.9	6.7	5.2	5.0	23.3	29.0
CDE-93	na	7.6	6.7	7.6	9.6	22.8	27.9

Note: The 2000 crop cotton was harvested using a stripper with a field cleaner, consequently it gave higher turnout based on lot weight at the gin suction.

Table 2. Means for HVI lint analysis results on lint after one lint cleaner, from the Lubbock, Texas USDA classing office, for the experimental gin stand with two ginning rates (paddle roll loadings of 8 and 11 amps) and a conventional gin stand, using cotton from the 1999 and 2000 crops.

Gin	PR amps	Staple	Mike	g/tex	Rd	+b	Length	Unif
			1999 crop cotton					
Exp-110	8	31.3	36.5	29.3	77.3	8.9	97.8 a	79.8
Exp-110	11	30.5	36.3	28.7	77.0	9.0	95.5 b	79.5
CDE-93	na	30.5	36.8	29.5	77.3	8.9	95.3 b	80.0
			2000 crop cotton					
Exp-110	8	32.2	36.7	27.4 b	67.2	10.5	100.8 a	80.0 ab
Exp-110	11	32.2	37.3	28.0 a	67.0	10.4	100.7 a	80.7 a
CDE-93	na	31.7	37.1	27.2 b	67.1	10.4	99.2 b	79.6 b

Note: Variables that were statistically different by the REGWQ procedure of SAS GLM are indicated by different letters following the numbers. There were no differences due to replication.

Table 3. Results for of lint samples taken after one lint cleaner, evaluated by the AFIS system at the International Textile Center, Texas Tech University, for the experimental gin stand at two ginning rates (paddle roll loadings of 8 and 11 amps) and a conventional gin stand, using machine-stripped cotton from the 1999 and 2000 crops.

AFIS data	Experimental gin stand, & PR load 8 amps	11 amps	Conventional gin stand
	1999 crop cotton		
Nep Cnt/g	510.67	505.50	495.83
Nep [um]	723.8	727.7	734.0
SCN Cnt/g	23.8	26.3	24.5
SCN (um)	913.5	981.8	992.3
Mean trash size (um)	429.0	443.5	430.2
Total Cnt/g	383.7	431.3	407.0
Dust Cnt/g	274.0	309.5	295.7
Trash Cnt/g	109.8	122.0	111.5
AFIS VFM, %	1.91	2.38	2.26
L(w) (in)	0.83 a	0.81 b	0.82 b
L(w) (% cv)	34.4 b	35.7 a	34.8 ab
SFC(w) %	12.6 b	14.7 a	13.9 a
UQL (in)	1.01	0.99	1.00
Mat. Ratio	0.88	0.87	0.87
IFC %	6.88	7.18	7.27
Fineness (mtex)	166.8	164.8	165.5
	2000 crop cotton		
Nep Cnt/g	455.00	441.56	453.78
Nep [um]	712.3	716.1	702.6
SCN Cnt/g	22.6 ab	27.1 a	19.7 b
SCN (um)	948.4	918.7	914.4
Mean trash size (um)	407.3	426.9	412.1
Total Cnt/g	454.6 b	554.8 a	504.4 ab
Dust Cnt/g	327.6 b	402.2 a	373.1 a
Trash Cnt/g	127.0 b	152.3 a	131.2 b
AFIS VFM, %	2.11 b	2.90 a	2.47 ab
L(w) (in)	0.86 a	0.85 a	0.84 b
L(w) (% cv)	34.4 b	34.8 b	36.0 a
SFC(w) %	11.6 b	12.4 b	13.9 a
UQL (in)	1.04	1.04	1.03
Mat. Ratio	0.87	0.86	0.86
IFC %	7.06	7.33	7.21
Fineness (mtex)	167.2	165.3	164.7

Note: Statistical differences between gin stand treatments for an AFIS measurement, indicated by the REGWF procedure of the SAS system at the 95 percent level, are shown by different letters following the data. L(w) represents the upper half mean fiber length by the weight of fibers. AFIS also reports the upper half mean length value by number of fibers L(n), not shown, which gave the same statistical result. The IFC is the AFIS evaluation of the percentage of immature fibers in the sample.

Table 4. Results from ginning tests with the experimental gin stand operating at different paddle roll power levels and the conventional gin stand with a firm seed roll. The data are averages for the test that also used three seed finger speeds and three cotton lots in a random block design.

Gin stand	PR load amps	Ginning rate bales/hour	Power use kWh/bale	Turnout %	Additional lint, %
Exp-110	14	5.4 e	7.7 c	26.4 ab	3.5
	16	7.1 c	7.9 c	27.6 a	7.7
	18	8.7 b	8.3 c	27.0 ab	5.6
	20	9.5 a	9.1 b	27.5 a	7.4
CDE-93	na	6.4 d	13.3 a	25.4 b	0

Note: Statistical differences indicated between gin stand treatments for a test response by the REGWF procedure of the SAS system at the 95 percent level are indicated by different letters following the data.

Table 5. Results from ginning tests with the experimental gin stand operating with different seed finger speeds and the conventional gin stand with a tight roll. The data are averages for the test across all paddle roll loadings and three cotton lots in a random block design.

Gin stand	Seed finger Speed, rpm	Ginning rate bales/hour	Power use kWh/bale	Turnout %
Exp-110	7.5	7.7 b	8.4 b	27.3 a
	11.5	8.2 a	8.1 b	27.2 a
	13.5	8.0 ab	8.4 b	27.1 a
CDE-93	na	6.4 c	13.3 a	25.4 b

Note: Statistical differences between gin stands by the REGWF procedure of the SAS system at the 95 percent level for a test response are indicated by different letters following the data.

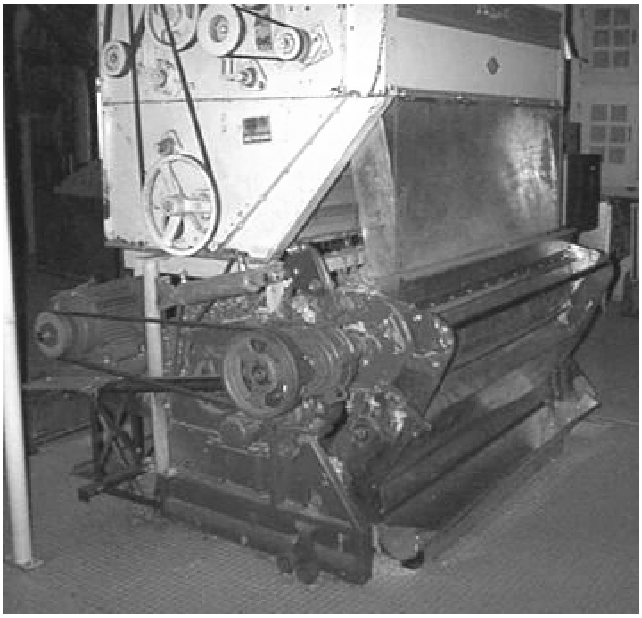

Figure 1. The experimental powered paddle roll gin stand showing the drive for the paddle roll and the new gin front assembly.

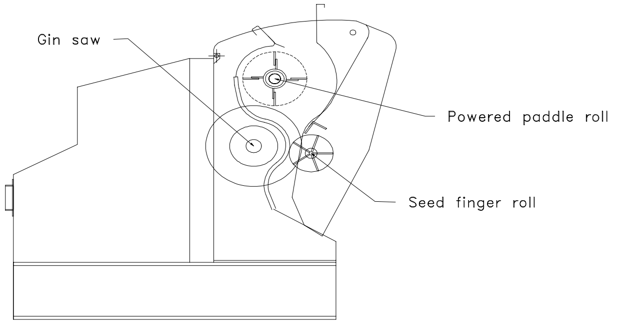

Figure 2. Schematic drawing of the powered paddle roll gin stand showing the reshaped roll box and the rotating seed finger roll.