2243 HIGH-SPEED ROLLER GINNING IN COMMERCIAL GIN PLANTS IN 2005 AND 2006

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ABSTRACT. *Numerous conventional roller gin stands were modified to run at high speed in commercial ginning plants in 2005 and 2006. The high-speed stands ginned both Pima and upland cotton. Results from a field test at a commercial ginning plant that compared roller ginning (including one high-speed stand) and saw ginning using one upland cultivar showed that HVI color grade, staple length, uniformity, and fiber value were improved when using the roller gin stands. Results from the 2006 California crop showed similar improvements in staple length and uniformity when comparing roller-ginned upland cotton (which included conventional and high-speed stands) and saw-ginned upland cotton. Textile mills that value the significance of improved fiber properties were willing to pay a premium for roller-ginned upland cotton. Evaluation of high-speed roller ginning in commercial ginning plants will continue in 2007.*

Keywords. *Roller ginning, Upland cotton, Pima cotton, Fiber quality, Cottonseed quality.*

INTRODUCTION

Roller ginning has historically been used to gin only Pima cotton. Pima has inherent fiber advantages over upland cotton such as length, strength, and fineness. Roller ginning on a production per-unit-width basis is about five times slower and therefore more expensive than saw ginning, but because the value of Pima cotton is considerably higher than upland cotton (USDA, 2007), the higher cost of roller ginning Pima cotton is justified.

Roller ginning compared to saw ginning produces fiber of better quality. Hughs and Lalor (1990) showed that roller ginning different cultivars of cotton improved fiber length, length uniformity, and nep count when compared to saw ginning. Armijo and Gillum (2007) showed that roller ginning upland cotton, when compared to saw ginning, produced upland fiber that was more than one staple length longer, had fewer short fiber and neps, and higher turnout. However, upland cotton has a higher fiber-to-seed strength of attachment than Pima cotton and is more difficult to gin, adding to the already higher cost of roller ginning.

Armijo and Gillum (2007) showed that it is possible to roller gin upland cotton at a rate nearly equal to a conventional saw gin stand. They also showed that the horsepower requirement of the high-speed roller gin stand was equal to that of a conventional saw gin stand. The high-speed roller ginned upland cotton had the same fiber quality advantages as conventional roller ginning in that it did not damage the fiber. In the study by Armijo and Gillum (2007), bale value was not significantly different between roller and saw ginning, but this was because the pricing system does not reward for upland cotton staple lengths longer than 37, and there is no premium for lesser amounts of short fiber. However, export markets, which now use about 75% of U.S. upland cotton, value the significance of increased staple length and decreased short fiber and neps, and some textile mills are paying an extra 13 to 26 cents/kg (6 to 12 cents/lb) for roller ginned upland cotton.

In the 2007 study by Amijo and Gillum, a Consolidated HGM roller gin stand was converted from conventional speed to high speed. This research was a cumulative effort that had built upon earlier work that determined the optimum designs of the rotary knife (Gillum and Armijo, 2000 and Armijo et al.,

2004) and stationary knife (Armijo and Gillum, 2005). After work was completed on the Consolidated HGM roller gin stand, interest from the ginning industry led to a field test that converted a Lummus roller gin stand to high-speed. The motivation for research on high-speed roller ginning was to make it more feasible to gin upland cotton, but the benefit of running high speed also allowed Pima cotton to be ginned at a higher rate.

The objective of this paper is to briefly describe the changes needed to convert a conventional roller gin stand to a high-speed roller gin stand, and to discuss how high-speed roller ginning has been implemented in commercial gin plants during the 2005 and 2006 ginning seasons.

EQUIPMENT SETUP

Armijo and Gillum (2007) have documented converting a conventional 1-m (40-in.) wide Consolidated HGM roller gin stand and feeder to high speed. A conventional Lummus Rota-Matic roller gin stand and feeder was also converted to high speed by Armijo and Gillum (a description of the conversion has not yet been published). Both conversions were completed at the USDA-ARS Southwestern Cotton Ginning Research Laboratory located in Mesilla Park, NM. Although there were minor differences between the conversions on the Consolidated and Lummus roller gin stands and feeders, the modifications are summarized as follows:

- The path of seed cotton in the feeder was modified to allow a higher throughput of seed cotton (figure 1).
- The motor on the main drive was increased from 11 kW (15 hp) to 37 kW (50 hp).
- The running frequency of the ginning roller was increased from about 120 rpm to 375 rpm.
- The running frequency of the rotary knife was increased from about 425 rpm to 1300 rpm.
- The force between the roller and stationary knife was increased from about 11 kN/m (63 lb/in.) to 15 kN/m (85 lb/in.).
- An air-fed plenum and cooling nozzle apparatus was added to the rear of the gin stand to cool the ginning roller (figure 2). A 3.7 kW (5 hp) auxiliary blower supplied the air.
- The lint flue transition exiting the gin stand was enlarged (figure 3).
- An automatic computer control [that included a 2.2 kW (3 hp) auxiliary motor to drive the rotary knife] was added to monitor and adjust the feed rate of seed cotton to the gin stand.

Commercial roller ginning plants in Arizona, California, and New Mexico converted numerous conventional roller gin stands and feeders to high speed during the 2005 and 2006 ginning seasons. In 2005, one Arizona ginning plant converted a conventional roller gin stand to high speed. All of the remaining conversions occurred in 2006. Some of the roller ginning plants in California and New Mexico made only partial conversions to their equipment. These partial conversions consisted of only increasing the throughput of seed cotton in the feeder, or only slightly increasing the speed of the ginning roller and rotary knife (but not by enough to require a cooling system). The partial-conversion roller gin stands and feeders did not achieve the same ginning rate as the full-conversion high-speed stands. The partial-conversion stands were estimated to gin at about 436 kg m^{-1} h^{-1} (2 bales m^{-1} h^{-1}) compared to about 1000 kg m^{-1} h^{-1} (4.5 bales m^{-1} h^{-1}) on a fully-converted stand. During the 2006 ginning season, two full-conversion high-speed roller gin stands operated in Arizona, and 14 operated in California. During the same year (2006), 52 partial-conversion stands operated in California and four in New Mexico. Table 1 shows the makeup of high-speed roller ginning in 2006.

Field Test Setup

A field test was conducted during the 2005 ginning season in the Gila River Valley of Southeastern Arizona to determine the operating characteristics of a roller gin stand converted to high speed, and to compare roller versus saw ginning of upland cotton. As mentioned earlier, the motivation for conducting research on high-speed roller ginning centered on roller ginning upland cotton. A conventional roller gin stand was converted to high speed at the Glenbar Gin in Pima, AZ. The converted roller gin stand was one of 12 stands at the Glenbar Gin.

The Glenbar Gin is a combo gin that has both roller and saw gin stands, but utilizes the same overhead (seed-cotton cleaning and drying) and press. The gin equipment at the Glenbar Gin was manufactured by the Lummus Corporation. The overhead included three 6-cylinder inclined cleaners and two tower dryers. The roller gin had 12 roller gin stands; one of these stands was converted to high speed for the field test. (Another roller gin stand was converted to high speed in 2006 after the field test was completed.) Lint cleaning in the roller gin included two 6-cylinder inclined cleaners. The saw gin had two 158 saw gin stands, each followed by one saw-type lint cleaner.

Cotton used for the field test included 164 bales of FiberMax 989RR upland cotton. The cotton was grown in one field by the same producer, and harvested with the same picker, i.e. the same growing and harvesting conditions apply to all 164 bales. Seventy-seven bales were roller ginned (including one high-speed stand) and 87 bales were saw ginned (two treatments). Analysis of variance was performed with the General Linear Model (GLM) procedure of PC-SAS (SAS, 2003) with a 5% level of significance. Fiber properties of the 153 bales were determined by the High Volume Instrument (HVI) at the USDA-AMS Phoenix Classing Office.

In addition to results from the field test in Arizona, HVI fiber properties from the California cotton crop of 2006 are presented. The California results include fiber properties of roller-ginned upland cotton.

Field Test Results

Prior to running the field test, about one module of upland cotton (12 bales) was ginned to check the initial start-up of the high-speed roller gin stand. The high-speed stand roller gin averaged a ginning rate of 1046 kg m^{-1} h^{-1} (4.8 bales m^{-1} h^{-1}). This compares to a ginning rate on a conventional roller gin stand of about 273 kg m^{-1} h^{-1} (1.25 bales m^{-1} h^{-1}). During start-up, the high-speed roller stand performed well. Roller temperature averaged about 938C (2008F), and there were no choke-ups. The only modification made at start-up involved changing a sheave on the feed-rollers drive on the feeder to increase the throughput of seed cotton.

Treatment means and observed significance levels of the HVI fiber properties from the field test are shown in table 2. Leaf grade, micronaire, and strength were not different between roller and saw ginning treatments and averaged 2.66, 3.56, and 29.5 g/tex, respectively. Color grade was different between ginning treatments, averaging 104.7 and 104.3 (old code) on the roller and saw gin, respectively. These color grades equate to a new code color grade of 11 and 21 for the roller and saw gin, respectively. Reflectance and yellowness were different between ginning treatments. Reflectance averaged 81.3 and 82.4 on the roller and saw gin, respectively, and yellowness averaged 8.78 and 8.04 on the roller and saw gin, respectively.

Fiber length and length uniformity were different between ginning treatments. Fiber length averaged 27.8 and 27.1 mm (1.094 and 1.066 in.) on the roller and saw ginning treatments, and staple length averaged 35.3 and 34.2 in. on the roller and saw gin, respectively. (Fiber staple length is an industry-wide used measure and that is why it is reported in English units.) One of the benefits of roller ginning is improved fiber length, which may be important in meeting world quality standards of 35 staple length. Uniformity averaged 80.2 and 79.7 on the roller and saw gin, respectively. This difference was somewhat less then expected as Armijo and Gillum (2007) found the roller ginning had about two percent more uniformity than saw ginning. Loan value of the fiber was significantly different between roller and saw ginning. Loan value averaged 1.26 \$/kg (57.0 cent/lb) on roller ginning and 1.21 \$/kg (54.8 cent/lb) on saw ginning. Loan value was based on the Commodity Credit Corporation loan value for the 2005 crop.

Table 3 shows the fiber quality of cotton classed at the USDA-AMS Cotton Classing Office in Visalia, California, during the 2006 ginning season. The results include roller-ginned upland cotton (91,307 bales), saw-ginned upland cotton (600,239 bales), and roller-ginned Pima cotton (720,215 bales). The roller ginning results include conventional and high-speed roller ginning combined. Comparing roller-ginned upland cotton to saw-ginned upland cotton, there was no difference in color grade or leaf grade, averaging 31 and 2, respectively. Roller-ginned upland cotton was about 2 mm (0.07 in.), or two staple lengths (39.6 versus 37.3) longer than saw-ginned upland cotton. Uniformity of roller-ginned upland cotton was 1.7% higher than saw-ginned upland cotton. These HVI results on length and uniformity are similar to those found by Armijo and Gillum (2007). In 2006, commercially roller ginned upland cotton received a premium of 13 to 26 cents/kg (6 to 12 cents/lb).

One item that cannot be tested in the laboratory is life of the ginning roller. In a 4-year field study that investigated roller life at a commercial roller ginning plant, Gillum and Armijo (1995) found that roller life on conventional roller gin stands had a high coefficient of variation (31%) and ranged from 219 to 1297 h. Considering that a conventional roller gin stand processes seed cotton at about 273 kg m^{-1} h^{-1} (1.25 bales m^{-1} h^{-1}), this equates to a range in roller life during this study of 175 to 1038 bales per roller. Reasons for unusually short roller life included damage by scrap metal or spindle twist, or premature wear-out due to a high roller surface temperature. Gillum and Armijo (1995) also found that cooling the roller by blowing ambient air onto it reduced roller temperature rise above ambient by 39% and increased roller life by 24%. A roller cooler is definitely needed on a high-speed roller gin stand due to higher levels of frictional heat generated between the ginning roller and the stationary knife. Because lint at the ginning point carries away some of the heat (the lint, rather than the roller, is sliding under the stationary knife), it is very important to start feeding the stand immediately upon startup to avoid burning up a roller. It is too early to determine roller life associated with high-speed roller ginning, but estimates by industry personnel who used high-speed roller ginning in 2006 report roller lives of 800 to 1000 bales per roller. This compares to estimates of roller life of 1000 to 1200 bales per roller found with conventional roller ginning.

A survey taken in the spring of 2007 of California roller ginning plants projected that there will be 21 additional high-speed roller gin stands, and 48 partially-converted roller gin stands used during the 2007-08 ginning season in California (CCGA, 2007).

CONCLUSIONS

Converting a conventional roller gin stand to high speed included the following: modifying the feeder to accept an increased throughput; increasing the speed of the ginning roller and rotary knife; increasing the force between the ginning roller and stationary knife; increasing the horsepower required to drive the ginning roller and feeder; adding an apparatus to cool the ginning roller; enlarging the lint flue; and adding a computer control to monitor the rotary knife. A roller gin stand may be partially converted by modifying only one part of the stand such as speeding up the ginning roller and rotary knife, but ginning rate will only be increased slightly

In a previous laboratory study, it was found that roller ginning at high speed did not damage or degrade cotton fiber. A 2005 field study verified the improvements in fiber quality obtained when roller ginning upland cotton; one high-speed roller gin stand was part of the study. Fiber properties from the 2006 California crop also verified the benefits of roller ginning upland cotton. Fourteen full-conversion, and 52 partial-conversion high-speed roller gin stands were used in the California crop.

New markets may open up due to the improved fiber quality of roller ginned upland cotton. In 2006, commercially processed roller ginned upland cotton received a premium of 13 to 26 cents/kg (6 to 12 cents/lb). Numerous roller gin stand conversions are planned for the 2007-08 ginning season. A better evaluation of roller life will ensue as more high-speed roller gin stands are used.

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Table 1. Makeup of high-speed roller gin stands during the 2006 season.

State	No. of Roller Ginning Stands	Type of Conversion
Arizona	2	Full
California	14	Full
California	52	Partial
New Mexico	4	Partial

Table 2. Treatment means and statistical analysis of USDA-AMS Classing Office results and loan value on bale samples of upland cotton from the Glenbar Gin Co.

	Treatment		
Measurement	**Roller Ginning**	**Saw Ginning**	**Observed Significance Level[a]**
Color grade, Index[b]	104.7	104.3	0.0113
Leaf grade, Index	2.65	2.66	NS
Micronaire, Reading	3.56	3.56	NS
Length, (mm) (in)	27.8 (1.094)	27.1 (1.066)	<.0001
Staple length, (32nd in)[c]	35.3	34.2	<.0001
Strength, (g/tex)	29.5	29.5	NS
Uniformity, (%)	80.2	79.7	<.0001
Reflectance, Rd	81.3	82.4	<.0001
Yellowness, +b	8.78	8.04	<.0001
Loan Value, ($/kg) (cent/lb)[d]	1.26 (57.0)	1.21 (54.8)	<.0001

[a] NS = not statistically significant at (P>0.05).

[b] Upland old code index, 100=31, 104=21,105=11.

[c] Staple length in 32's of an inch is an industry wide unit of measure.

[d] 2005 Commodity Credit Corporation loan chart.

Table 3. Fiber quality from 2006-07 California cotton crop.

	Ginning type and cultivar		
	Roller Ginned Upland	**Saw Ginned Upland**	**Roller Ginned Pima[a]**
Measurement	**91,307 bales**	**600,239 bales**	**720,215 bales**
Color grade, Index[b]	31	31	2
Leaf grade, Index	3	3	2
Micronaire, Reading	4.51	4.21	3.99
Length, (mm) (in)	31.4 (1.237)	29.6 (1.167)	35.3 (1.390)
Staple length, (32nd in)	39.6	37.3	44.5
Strength, (g/tex)	34.2	33.8	40.1
Uniformity, (%)	84.1	82.4	85.1

Reflectance, Rd	77.2	78.9	70.6
Yellowness, +b	8.75	8.13	11.39

[a] Includes 67,013 bales from AZ, NM, and TX.

[b] Index system is different for Upland and Pima cotton.

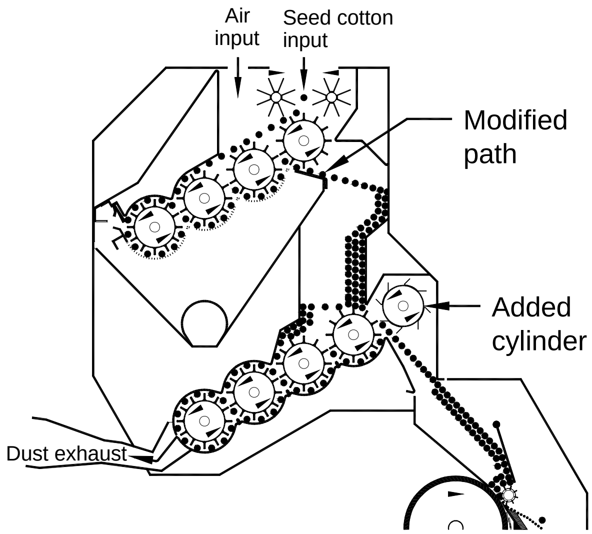

Figure 1. Modified Consolidated HGM seed-cotton feeder.

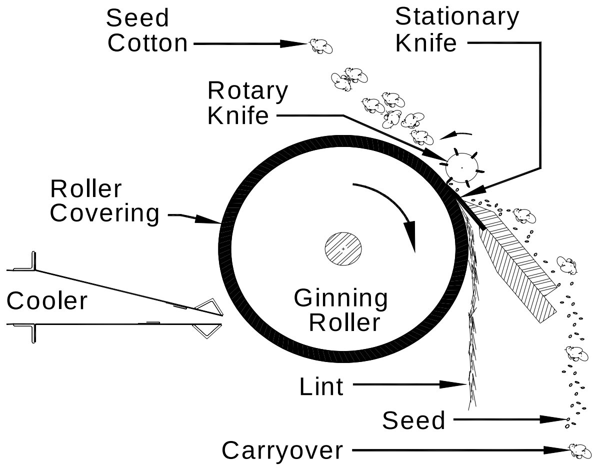

Figure 2. Auxiliary roller cooler on the Consolidated HGM roller gin stand.

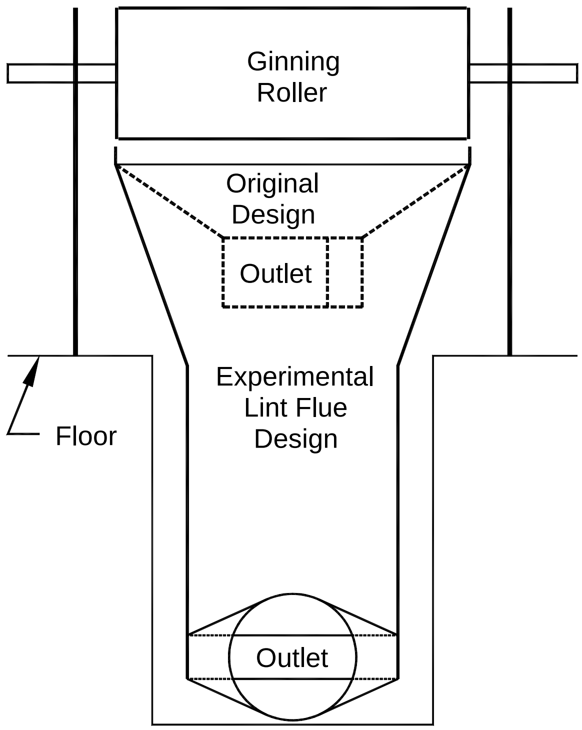

Figure 3. Enlarged (experimental) lint flue exiting the Consolidated HGM roller gin stand.