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EVALUATION OF MODERN HIGH-CAPACITY GIN STAND AND LINT CLEANER PERFORMANCE

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Abstract

Side-by-side samples were taken from competitive lines of ginning/lint cleaning machinery under the same Conveyor Distributor to evaluate performance with regard to gin stand seed cleaning, lint cleaning, and fiber spinning quality properties. Additionally, lint cleaning results from a second test site are presented. This site highlights the first tandem installation of Lummus Sentinel™ lint cleaners in the world, in order to quantify the fiber quality properties after single and two-stage saw type lint cleaning using this non-conventional saw-type lint cleaner. This study is being done to demonstrate the benefits to growers and textile mills alike of working with gins that maximize performance through the use of high-capacity machinery while not overly damaging cotton's valuable spinning properties.

Background

Saw Gin Stands

State-of-the-art saw gins have evolved significantly over the last several years with the demand for cotton gins to produce bales at ever-increasing rates and demands to meet changes in the characteristics of the seed cotton cultivars. But in this rush to meet these needs, some important performance factors must be more carefully monitored, and gin equipment should be updated to meet the changing conditions. In addition to the demands for higher capacity ginning, new cotton varieties with ever-decreasing seed size and seed weights per bale require gin stand modifications. The continuing trend toward fewer gin plants, but larger and larger annual productions is causing greater demands on the wearing parts of the gin stands. Longer-lasting gin saws and ribs at higher ginning capacities are needed.

One of the primary factors of gin plant performance that should be monitored is of considerable economic importance: it is lint turnout per pound of seed cotton. This is often overlooked, because it is difficult to compare the relative turnouts of one gin against another. This difficulty to make comparisons is exacerbated by the wide range of the percentage of seed weight per bale among the varieties of cotton grown in a given ginning area. The percentage of fiber removed from the seed by a gin stand results from the basic gin stand design, but it is also greatly influenced by the condition of the gin saws. While it can be tempting for a gin to delay replacing saws beyond their most efficient lint removal condition, this practice can result in substantial amounts of residual lint being left on the seed, due to the poor seed-cleaning action of the dull saws. This is of enormous economic consequence to the producer, and yet it is often undetected. In fact, had it not been that the excessive lint left on the seed sold to the dairy industry caused problems with the seed emptying from the tilted trucks, high residual seed lint may not have gained the publicity it has received recently.

An easy way to assure that a given gin point is properly ginning the fiber off of the seed is to send samples of the seed to an analysis laboratory, such as Hahn Laboratories, Inc. of Columbia, South Carolina. For a modest fee, such laboratories will analyze your seed for percent lint content (by weight). If it is over ten percent (10%), it is time either to change saws or, if the saws are relatively new, evaluate gin stand design. While current gin saws can last from 8,000 to 10,000 bales per gin stand, recent poor-quality steel in the raw material marketplace has caused inferior saws to make their way into the supply stream. Therefore, gin saws should be checked beginning at around 2,000 bales per stand to assure that the well-ginned seed is being produced.

Gin ribs have also undergone modifications to provide longer-wearing ribs as well as to adapt to the smaller seeds. However, there seems to be no end to the breeders reducing seed size to produce high yields. Therefore, since an increasing amount of small seed passes out of the gin stands with the lint, gins should have efficient moting systems

and should be followed by air-type lint cleaners (like the Lummus Super-Jet®) to reduce the amount of seed that passes on to the saw-type lint cleaners.

To demonstrate the points discussed above, in late 2003, though it not a part of the studies reported in this paper, two gin installations in close proximity to each other, processing seed cotton from the same fields, had samples from their respective seed piles analyzed for residual lint content. One facility featured Lummus' latest 170-Saw Imperial III gin stands, while the other had the latest model of a competitor's gin stands. The Lummus seed tested 9.1% lint by weight, as compared to 13% lint by weight of the competitive ginned seed. The seed cotton being ginned averaged around 775 pounds of seed per bale. The difference of 3.9% lint on the seed at 775 pounds bale amounted to an astounding 30.2 pounds of lint on the seed that should have gone into the bales of the competitive gin. Over a 30,000-bale season, this would amount to 906,000 pounds of additional lint or 1,812 additional bales of cotton!

Gin stands over ten years old have wider saw spacing than current models. For example, Lummus gins of the same width have changed over the years from 128 saws to 158 saws to the current 170-Saw Imperial III gin (introduced in 1994). Competitive gins have made similar increases in their saws per stand. In addition to the saw spacing, state-of-the-art gins have made other modifications to improve the seed reclaiming areas of the gin stand. Attempting to gin at higher capacities with older models often results in seed that is not fully ginned, which can severely cost the producer, as was demonstrated above.

Saw-Type Lint Cleaners

Saw-type lint cleaners were introduced in cotton gins shortly after World War II, when mechanical harvesters began to replace hand-harvesting, resulting in unprecedented amounts of trash and moisture being brought to the gins with the seed cotton. A typical controlled-batt, saw-type lint cleaner (the Lummus Model 108) is shown in Figure 1.

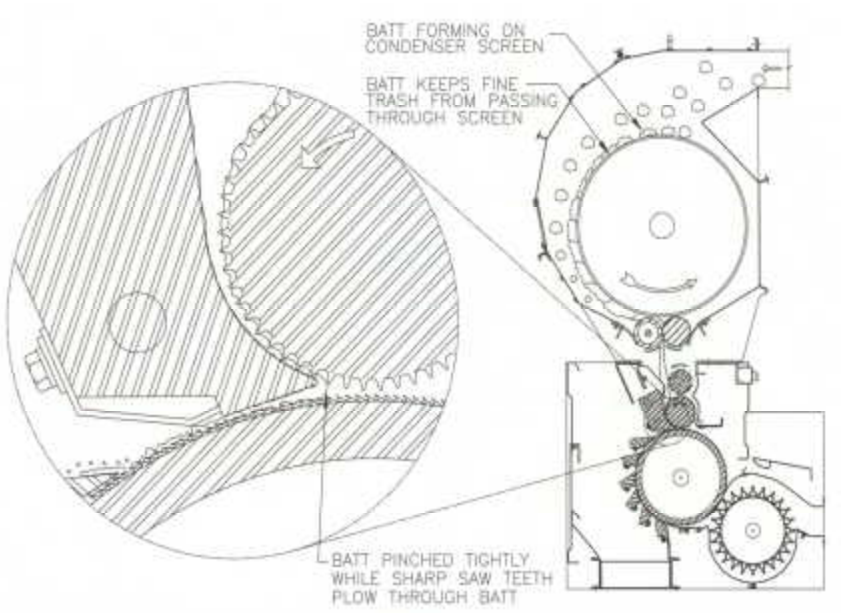

Figure 1. Cross-section of controlled-batt, saw-type lint cleaner (Lummus Model 108).

These lint cleaners operate under the principle that the lint is formed into a batt by a slow-moving condenser drum, fed through a series of rollers (the feed works), then applied to the high-speed saw cylinder teeth by a closely-spaced feed roller and feed plate. The difference in speed of the batt versus the saw speed at the transfer point is known as the combing ratio and is what results in the smooth appearance of the lint following one or more stages of saw-type lint cleaning. Over the years, many tests have been run on saw-type lint cleaners, and it has been positively determined that considerable fiber breakage takes place in these machines. Further, these studies shows that almost all of the fiber breakage takes place in saw-type lint cleaners where the sharp saw teeth plow through the firmly-held batt of fibers being fed to the saws.

Lummus engineers, working with the USDA Mesilla Park ginning lab and Cotton Incorporated developed a saw-type lint cleaner, which feeds the individual tufts of fiber onto the lint cleaner saw, rather than condensing the lint into a batt. This "batt-less' lint cleaner, known as the Sentinel™ lint cleaner (see Figure 2), was introduced to the market in 1999 (Rutherford, et. al., 1999).

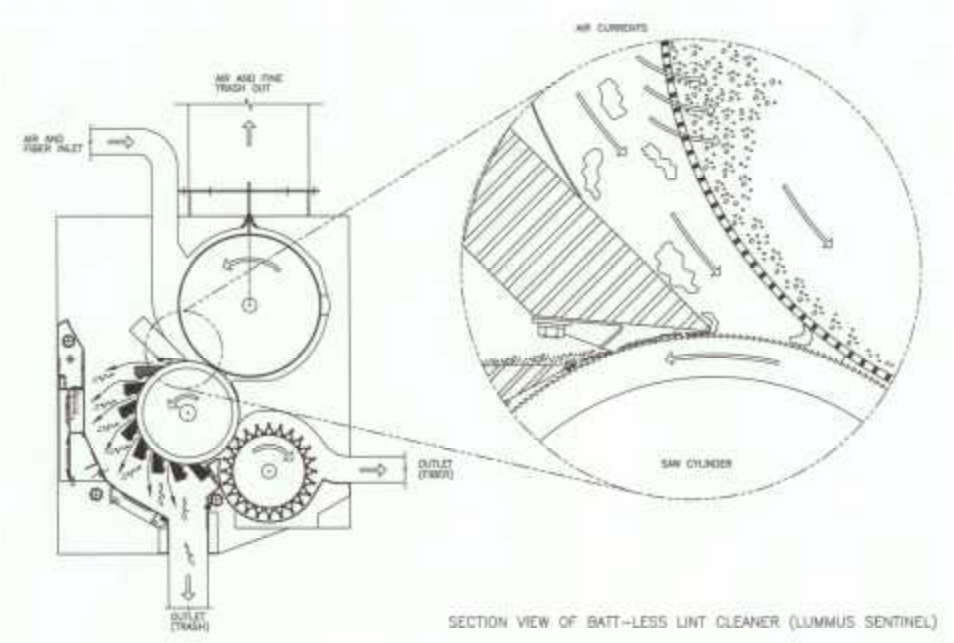

Figure 2. Cross-section of the Lummus Sentinel™ lint cleaner.

A salient and critical feature of the Sentinel™ is that the high-speed perforated air separator cylinder, which delivers the lint to the saw, removes considerably more dust and very fine trash as compared to conventional controlled-batt lint cleaners, in which the batt filters the dust and trash back into the lint as it forms on the condenser drum. The superior color produced by the Sentinel™ is more pronounced as the harvesting season progresses and the open cotton is held longer in the fields. Colorimeter charts typically demonstrate the superior dust removal of the Sentinel™.

Over these past five years of operation, several tests have been run comparing the Sentinel™ with conventional controlled-batt lint cleaners (Rutherford, et. al., 2002 and Rutherford, et. al., 2004). These tests confirm that the Sentinel™ not only does less fiber breakage, but also causes fewer neps. The lower fiber breakage is reflected in the staple length (L), uniformity index (UI), short fiber content (SFC), upper half mean (UHM), and upper quartile mean (UQM). Overall trends generally indicate that there is only about one half of the damaging effect from the Sentinel™ compared to the conventional saw-type lint cleaners.

2004 Testing

All tests to date had only evaluated single-stage saw-type lint cleaner damage and only comparing the Sentinel™ to Lummus' Model 108 lint cleaners. Prior to 2004, the Sentinel™ lint cleaner had only been installed in tandem arrangements as a first stage saw-type lint cleaner, followed by a conventional Lummus Model 108 lint cleaner in the second stage (see Figure 3).

Figure 3. Tandem lint cleaning arrangement with Sentinel™ lint cleaner (left) and Model 108 lint cleaner (right).

Plant Installations

In the spring of 2004, the first tandem Sentinel™ configuration was installed next to a tandem arrangement of Sentinel™/Model 108 lint cleaners at Brighann Ginning in Moree, New South Wales, Australia. This provided the opportunity to compare the effect of two Sentinels versus the Sentinel™/108 combination on cleaning efficiency as well as fiber damage.

At Midway Gin Coop in Taft, Texas, a Lummus ginning/lint cleaning line consisting of a Model 700 II feeder, 170-Saw Imperial III gin, Super-Jet® lint cleaner and Sentinel™ lint cleaner was installed under the same conveyor distributor as a current model competitor's extractor feeder, gin stand, centrifugal lint cleaner and conventional saw-type lint cleaner (see Figures 4 and 5).

Figure 4. Installation of Lummus gin and feeder at Midway Gin Coop in Taft, Texas.

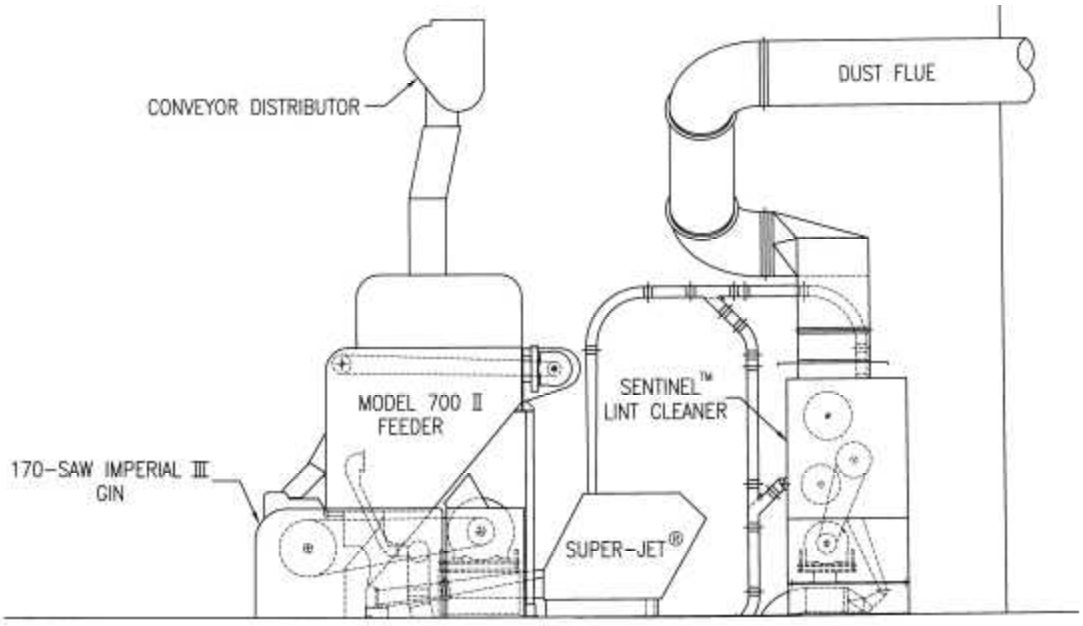

Figure 5. Layout of Lummus ginning/lint cleaning line at Midway Gin Coop in Taft, Texas.

The Midway installation allowed comparison of the performance of two current model gin stands on seed cleaning, along with the effect of the ginning/lint cleaning lines of two brands of late-model gin machinery on overall cotton quality.

Testing Protocol - Brighann

Simultaneous lint sampling took place in adjacent lines before and after the first stage Sentinel™ lint cleaners and after the second stage lint cleaners (either a Sentinel™ or Model 108, depending on the line). Five replications at each sampling point were performed, each sample identified with a code number, and HVI and AFIS analyses were done on all samples by the lab at Cotton Incorporated in Cary, North Carolina.

Testing Protocol – Midway

Two separate areas were sampled at Midway. First, ginned seed was simultaneously collected from the seed fall area of the Lummus 170 gin and the competitor gin stand, along with the seed tube discharge of the competitor gin stand. These seed samples were numbered and sent to Hahn Laboratories, Inc. in Columbia, South Carolina, for residual lint analysis. Second, simultaneous lint samples were taken before the Lummus Sentinel™ and competitor lint cleaner and after each. Five replications at each sampling point were done, samples numbered, and, like the Brighann samples, all were subjected to HVI and AFIS analyses at Cotton Incorporated.

Results

HVI and AFIS Results – Brighann

The HVI and AFIS results from the lint samples at Brighann are shown in Tables 1 and 2.

Table 1. HVI data for fiber samples from Brighann Gin (2004).

	Rd	+b	C Grade	SFC (%)	UHM (inches)	UI	Trash Area (%)
Sentinel™/Model 108							
After Gin	77.94	7.82	31-2 (4) 31-1 (1)	9.6	1.158	81.9	2.48
After Sentinel™	79.38	7.94	21-2 (3) 31-1 (2)	10.6	1.140	81.2	1.66
After Model 108	79.08	7.94	21-2 (1) 31-1 (4)	10.9	1.126	81.0	1.42
Sentinel™/ Sentinel™							
After Gin	78.42	7.90	31-1 (5)	9.2	1.162	82.5	2.06
After Sentinel™ #1	79.34	8.02	21-2 (3) 31-1 (2)	10.2	1.146	81.2	1.72
After Sentinel #2	80.32	8.02	21-2 (5)	10.5	1.144	81.1	1.28

Table 2. AFIS data for fiber samples from Brighann Gin (2004).

	L(w) (inches)	UQL(w) (inches)	SFC(w) (%)	L(n) (inches)	Dust (Cnt/g)	Neps (Cnt/g)	Trash (Cnt/g)	VFM (%)
Sentinel™/Model 108								
After Gin	1.036	1.264	8.26	0.788	474	199	562	1.77
After Sentinel™	1.028	1.258	8.66	0.766	346	267	415	1.37
After Model 108	1.006	1.236	9.62	0.748	345	312	412	1.51
Sentinel™/ Sentinel™								
After Gin	1.054	1.272	7.30	0.816	367	181	443	1.70
After Sentinel™ #1	1.036	1.260	8.26	0.782	346	231	425	1.80
After Sentinel™ #2	1.028	1.254	8.46	0.774	266	272	324	1.28

Ultimately, the most interesting results were those after the two stages of lint cleaning in each line. HVI results showed that the tandem Sentinel™ line samples showed a higher reflectance (Rd), slightly longer upper half mean (UHM), and less percentage trash area than the Sentinel™/Model 108 line. The Color Grade for all five final tandem Sentinel™ samples graded 21-2, while only one of the Sentinel™/Model 108 samples out of the five came in at 21-2 (the other four grading 31-1). This is a direct effect of the Sentinel's high-speed separator cylinder removing more dust from the lint, thus brightening the sample.

AFIS results were even more impressive for the Sentinel™. Length (L) was nearly two-thirds of a staple length longer after tandem Sentinels than after the Sentinel™/Model 108 group. Short fiber content (SFC) was over a percent less, while dust, neps and trash were all substantially less for the Sentinel™. These results validate that the Sentinel™, whether in single or tandem arrangement, does an efficient job of cleaning, while at the same time preserving the valuable fiber properties so much in demand by textile mills around the world.

Residual Lint Results – Midway

The residual lint analysis on the ginned seed samples from Midway are shown in Table 3.

Table 3. Ginned seed residual lint analysis for Midway Gin Coop (2004).

Seed Sampling Location	Residual Lint (w) (%)
170-Saw Gin Seed Fall	10.7
Competitor Seed Fall	11.5
Competitor Seed Tube	11.2

Although not nearly as dramatic a difference as the gin plant comparison discussed earlier in this paper, the one-half of one percent difference in residual lint between the Lummus 170 gin and the competitor seed tube would result in

between three and four pounds of lint per bale of lint remaining on the seed with the competitor gin stand. It is important to note that the cotton being ginned at the time of testing had been harvested in less-than-perfect moisture conditions and actually had some rotten seed, making ginning difficult at best. Also, both gin stands were equipped with gin saws manufactured by the competitor, and from the 10.7% residual lint on the Lummus stand, the saws were probably in need of replacement.

HVI and AFIS Results – Midway

The HVI and AFIS results from the exit points of both lint cleaners (prior to entering the lint flue) are presented in Tables 4 and 5.

Table 4. HVI data for fiber samples from Midway Gin (2004).

	C Grade	SFC (%)	UHM (inches)	UI	Trash Area (%)
Lummus Line	31-3	8.96	1.150	82.90	3.12
Competitor Line	31-3	9.26	1.140	82.70	2.72

Table 5. AFIS data for fiber samples from Midway Gin (2004).

	L(w) (inches)	UQL(w) (inches)	SFC(w) (%)	Neps (Cnt/g)	Trash (Cnt/g)	VFM (%)
Lummus Line	1.062	1.264	6.38	275	664	2.74
Competitor Line	1.038	1.246	7.56	283	584	2.41

HVI color grades for both lines were equal, while short fiber content (SFC), upper half mean (UHM), and uniformity index (UI) were all slightly favorable to the Sentinel™. Trash area was slightly less for the competitor line.

AFIS length (L) for the Sentinel™ was approximately one staple length longer, and AFIS short fiber content (SFC) (which is significantly more accurate than HVI SFC measurement) was over one percent less than the competitor line. Neps were also less with the Sentinel™, though not highly significant.

Summary

Late-model, state-of-the-art gin stands, when properly adjusted and maintained, offer exceptional capacity and performance in their from-the-factory configuration. Residual lint levels from nine to ten percent (9-10%) are realistically achievable, based on the gin stand's design and the condition of the gin saws and ribs, without the need for third-party modifications. Additionally, the Sentinel™ lint cleaner, whether in single or tandem arrangement, offers effective cleaning, in many cases superior to conventional saw-type lint cleaners. Also, the Sentinel™ provides excellent turnout and grade, along with lower short fiber content and nep counts, proving that these end results are not and do not have to be mutually exclusive.

In the global cotton marketplace today, textile mills will source the best quality cotton with the least amount of damage in order to maintain productivity and profitability – regardless of where it is produced. The gin plant is a pivotal link in this supply chain, since the job it does in processing the producer's seed cotton can determine success on both ends – the producer's and the mill's. Gins which suffer from poor lint turnout, whether it be from sub-standard seed cleaning in the gin stand or from improperly performing lint cleaners will not succeed in the long term. The attempts by some to mask the poor performance of one piece of equipment through the manipulation of another machine downstream in the process only put a short-term "patch" on a deeper problem. The current cotton classification/marketing system in many ways promotes this manipulation, rather than rewarding true spinning quality. It is hoped that, in the not-too-distant future, a cotton classification system reflecting true spinning quality will come into being, thus providing more incentive to develop new and better processing technologies in the cotton ginning industry.

Acknowledgements

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Disclaimer

Use of the names of the USDA, Cotton Incorporated, or Hahn Laboratories, Inc. does not constitute any endorsement of any machinery discussed in this paper by any of these organizations or their employees.

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