

EQUIPMENT SELECTION FOR RECOVERING FIBER FROM STRIPPER HARVESTED GIN WASTE

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Abstract

Previous studies have shown the quantity of recoverable fibers with the potential to be marketed as motes approaches 10 to 25 percent of gin trash by weight. As a result of these findings and practical experience from a commercial cotton gin, questions arose as to the best equipment setup needed to recover the largest quantity of mote quality fibers. In this study, nine machinery layouts were evaluated to determine the setup that produced the most “clean” fibers. The machinery layouts evaluated included gravity feeding, separators, cylinder cleaners, and extractors (stick machines). Results showed that machinery layouts that contained only cylinder cleaners with or without separators did not clean the fibers as well as layouts that contained at least one extractor. The setup that produced the “cleanest” fibers was one that contained two separators and two extractors. In addition to the quantity of “cleaned” fibers produced, AFIS data was obtained on all fibers reclaimed from each layout. The AFIS data showed short fiber contents ranging from 23 to 30 percent by weight and 53 to 63 percent by number and indicated some significant differences for certain parameters. Given that the fibers recovered are intended for inclusion into the mote bales and not the lint bales, the AFIS data did not indicate one machinery layout to be more desirable than another.

Introduction

Separating the byproducts from cotton gins, commonly referred to as gin waste or gin trash, into its various components of sticks, burs, leaf, fibers, and other organic constituents (i.e. sand, soil, and miscellaneous small particle organic matter) revealed beneficial characteristics and physical properties beyond those experienced when all the constituents were not separated (Holt et al., 2000). The benefits gained from separating the cotton gin byproducts (CGB) into its individual components was the impetus behind the COBY Process (Holt and Laird, 2002) and numerous other research studies investigating the potential use of CGB for applications ranging from a raw material in the manufacture of a hydromulch (Holt et al., 2005a; Holt et al., 2005b) to a fuel pellet used for heating homes and small businesses (Holt et al., 2006). Holt and Wedegaertner (2007) reported on a study that focused on using CGB as a fuel where gin waste from four gins (two from West Texas and two from the South) was reprocessed through conventional precleaning equipment. The results from the study revealed that an average amount of “cleaned” waste, which was primarily reclaimed fiber, was 15 percent of the total. These reclaimed fibers were examined by a mote buyer and determined to be a good source of motes.

As a result of the study and in conjunction with studies conducted by Charley Knabb at Three-Way Gin in Tunica, Mississippi, the findings from lab and field studies about the reclamation of fibers from gin waste were presented at two of the three gin schools conducted by the National Cotton Ginners Association in 2008. Inquires from attendees of the gin school presentations on the fiber recovery process centered on wanting to know the most effective sequencing of equipment in order to reclaim the most fibers from CGB. Thus, the objective of this study was to evaluate select process streams to see which one(s) would yield the most “clean” fiber. A secondary objective was to determine if the different equipment setups had an impact on the quality of fiber recovered.

Materials and Methods**Setup and Testing**

The CGB used in this study was produced from a commercial cotton gin in West Texas during the 2007-08 ginning season. The gin from which the CGB were obtained generates approximately 14 to 15 bales of motes per day, so the CGB used should have lower fiber content than CGB obtained from gins that do not bale their motes. Once obtained, the CGB were stored in cotton trailers under a storage shed until processing. Nine different equipment sequences

(treatments) were evaluated, they were:

1. Separator – Cylinder Cleaner – Cylinder Cleaner
2. Separator – Cylinder Cleaner – Separator – Cylinder Cleaner
3. Separator – Stick Machine – Cylinder Cleaner
4. Separator – Stick Machine – Separator – Cylinder Cleaner
5. Cylinder Cleaner – Cylinder Cleaner
6. Cylinder Cleaner – Separator – Cylinder Cleaner
7. Stick Machine – Cylinder Cleaner
8. Stick Machine – Separator – Cylinder Cleaner
9. Separator – Stick Machine – Separator – Stick Machine

The primary difference between some of the treatments was whether or not the material was fed by gravity or through a separator. All treatments that do not have separators listed were gravity fed. For example, Treatment 6 was a gravity fed cylinder cleaner which gravity fed another cylinder cleaner. Each test run consisted of processing approximately 159 kg (350 lb) of CGB through the equipment being evaluated. For the equipment used, the cylinder cleaners had six cylinders and each stick machine had three saws.

Data Collection

The data recorded for each run consisted of: 1) time, 2) ambient temperature, 3) relative humidity, 4) weight of CGB used, 5) waste catch from each piece of machinery, and 6) the amount of “clean” fibers (final catch weight). After each run, three subsamples of the recovered fiber were collected. One sample was sent to Cotton Incorporated’s facility in Cary, North Carolina for Shirley (ASTM, 2004) and Advanced Fiber Information System (AFIS) analyses, one sample fractionated at the gin lab, and one sample retained as backup in the event additional analyses are needed at a later date. The fractionation divided the “cleaned” recovered fiber sample into three categories: 1) fibers, 2) sticks and burs, and 3) fines.

Experimental Design and Data Analysis

This study was a completely randomized design with nine treatments. Each treatment was replicated three times. Standard analysis of variance techniques were used to determine the statistical significance among the treatments using Ryan-Einot-Gaberiel-Welsch multiple range test at the 95 percent confidence interval (release 9.1.3; SAS Institute Inc.; Cary, NC). The response variables evaluated from the data included: 1) Final Catch Weight, 2) Cleaning Efficiency, and 3) AFIS data.

Results and Discussion

Tables 1 and 2 show some of the data obtained from the testing. Table 1 contains the percent of initial material that made it through the treatment (i.e. End Catch) along with the amount of lint and trash contained in the End Catch from fractionation. Table 1 shows that treatments 6 and 1 contained the largest quantity of material recovered, 42.2 and 40.7 percent, respectively. The lowest quantity of material recovered was from treatments 9 and 4, respectively. The data shows that End Catches larger than 20 percent were obtained for all treatments where two cylinder cleaners were used. However, the same cylinder-cleaner-only treatments also showed trash contents in excess of 70 percent and lint contents below 30 percent. Thus, using only cylinder cleaners resulted in a sample laden with extraneous debris and fibers that were not clean enough to go to the mote press without further cleaning. Contrary to the cylinder cleaner only treatments, all End Catch samples from treatments containing at least one stick machine produced samples with less extraneous debris and lint contents ranging from 36 to 69 percent. Overall, the treatment with two stick machines, treatment 9, produced significantly more lint and less trash than any of the other treatments. The treatments with the highest average trash contents in the End Catch were treatments 5, 6, and 2 with trash contents of 80, 79, and 78 percent, respectively.

Table 1. Recovered fiber and trash data from hand fractionation of cotton gin byproducts (gin trash) processed through the nine different treatments evaluated in this study.

Treatment	Equipment Sequence ^z	End Catch (% of Total) ^y	Fractionated Lint in End Catch (%) ^x	Fractionated Trash in End Catch (%) ^w
1	Sep, Cyl, Cyl	40.7	27.9d	71.5b
2	Sep, Cyl, Sep, Cyl	34.6	21.3de	77.8ab
3	Sep, S/M, Cyl	14.7	58.2b	36.0e
4	Sep, S/M, Sep, Cyl	13.9	55.2b	42.5de
5	Cyl, Cyl	32.1	18.8e	80.5a
6	Cyl, Sep, Cyl	42.2	19.4de	78.7ab
7	S/M, Cyl	16.4	49.9b	46.7d
8	S/M, Sep, Cyl	16.6	36.2c	59.4c
9	Sep, S/M, Sep, S/M	13.5	68.7a	25.9f

(z) Sep = Separator; Cyl = Cylinder Cleaner; S/M = Stick Machine

(y) End Catch is the percent of the total input that made it through the processing equipment without being discarded into the waste streams of the processing equipment.

(x) Fractionated Lint in the End Catch is the average percent fibers recovered as a result of hand fractionation of three samples. Means in the same column followed by different letters are significantly different at the 95 percent confidence limit.

(w) Fractionated Trash in the End Catch is the average percent fines, sticks, and burs recovered as a result of hand fractionation of three samples. Summations of the fractionated lint and the fractionated trash that are less than 100 percent are the result of “invisible loss”. Means in the same column followed by different letters are significantly different at the 95 percent confidence limit.

Table 2 shows the AFIS data that exhibited significant differences for the treatments evaluated. The AFIS data was obtained by Cotton Incorporated, by processing the samples through the Shirley analyzer and then analyzing the cleaned fibers. The data show that the fibers recovered are suitable for inclusion into mote bales, but should not be incorporated back into lint bales, especially with short fiber content (SFC) values ranging from 23 to 30 percent by weight and 52 to 63 percent by number. Table 2 indicates that treatment 9 may have produced the cleanest cotton (Table 1), but it had significantly higher neps, seed coat neps (SCN), SFC, and smaller fiber lengths than some of the other treatments. Unlike the trends that were seen in Table 1 with the cylinder-cleaner-only treatments having the highest trash and the stick machine treatments having the cleanest material, Table 2 does not indicate specific equipment trends for the fiber property data. The SCN are higher for treatments 9 and 2, one has only stick machines and the other has only cylinder cleaners, with both having two separators in the process stream. The AFIS data was obtained more out of curiosity to see if there were differences of any “real” significance (i.e. is there an abundance of “good” fibers that remain in the waste stream). However, considering that the AFIS data is concerning recovered fibers from a gin’s waste stream, significant differences do not provide guidance on equipment selection (i.e. it does not mean much) since the fibers are going to a mote bale and not a lint bale.

Table 2. Advanced fiber quality information system (AFIS) data for the fiber recovered from the cotton gin byproducts (gin waste) processed through the nine treatments evaluated in this study.

Treatment ^z	Nep Size (um)	Neps (cnt/gm)	Lw (in) ^y	Ln (in)	UQL (in)	SFCw (%)	SFCn (%)	SCN (cnt/gm)
1	776b	1754c	0.787ab	0.533a	1.050a	23.6b	52.9c	104b
2	789ab	2467ab	0.730c	0.460c	0.993b	30.5a	62.2a	141ab
3	774b	1908bc	0.797a	0.520ab	1.057a	23.3b	54.3bc	105b
4	772b	2101bc	0.770abc	0.480bc	1.043a	26.6ab	59.2ab	118b
5	778b	2174bc	0.757abc	0.480bc	1.027ab	27.6ab	59.3ab	116b
6	776b	2219bc	0.763abc	0.500abc	1.020ab	26.2ab	56.5abc	120b
7	778b	1978bc	0.733c	0.457c	0.990b	29.9a	62.2a	113b
8	781ab	2099bc	0.74bc	0.463c	1.000b	28.8a	60.8a	117b
9	803a	2766a	0.743bc	0.450c	1.017ab	29.0a	62.6a	166a

(z) Means in the same column followed by different letters are significantly different at the 95 percent confidence limit.

(y) L = length by weight (w) and by number (n), UQL = Upper Quartile Length, SFC = Short Fiber Content by weight(w) and by number(n), and SCN = Seed Coat Neps.

Figures 1 through 4 show the amount of material recovered from each piece of equipment used in the best and worst two treatments in terms of cleanliness of the fiber recovered. The best two treatments were 9 and 3; the worst were 5 and 6. Treatments 9 and 3 had stick machines (extractors) as part of their configuration while treatments 5 and 6 only had cylinder cleaners. In Figures 1 and 2, the initial separators removed approximately 10 percent of the initial mass with the first stage stick machine removing a little over 60 percent. The second stage, in Figures 1 and 2 removed approximately 7 percent more material. The addition of the second separator in treatment 9 accounted for an additional 2 percent more matter being removed, which consisted

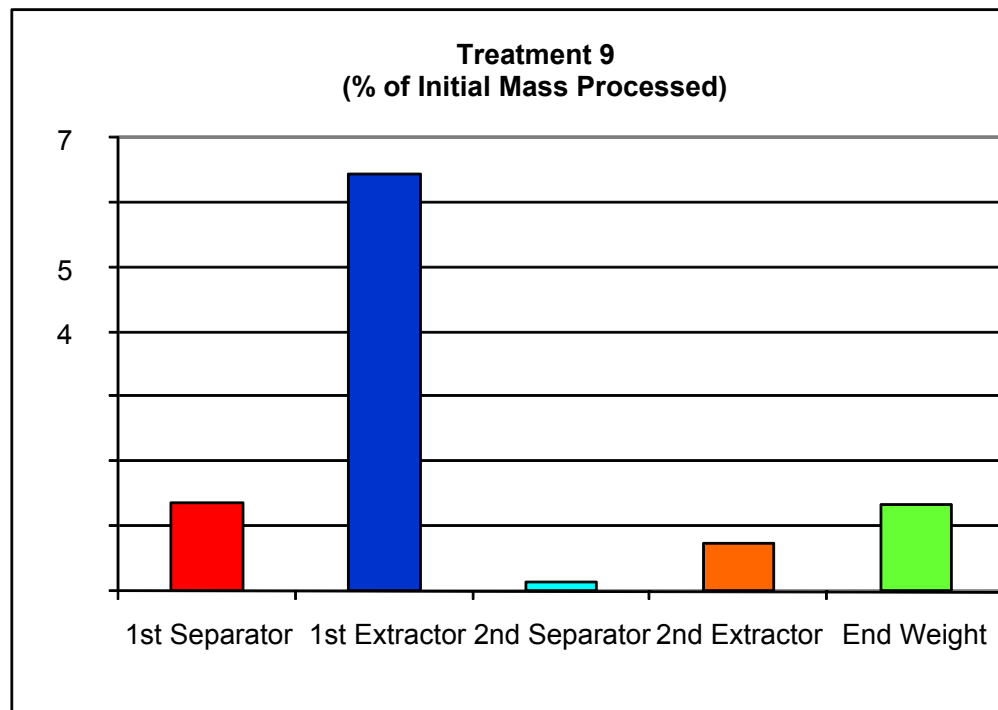


Figure 1. Bar graph of the percent of material produced from each piece of equipment used in processing the cotton gin byproducts for treatment 9. The End Weight is the percent of the original material that made it through all the processing equipment used.

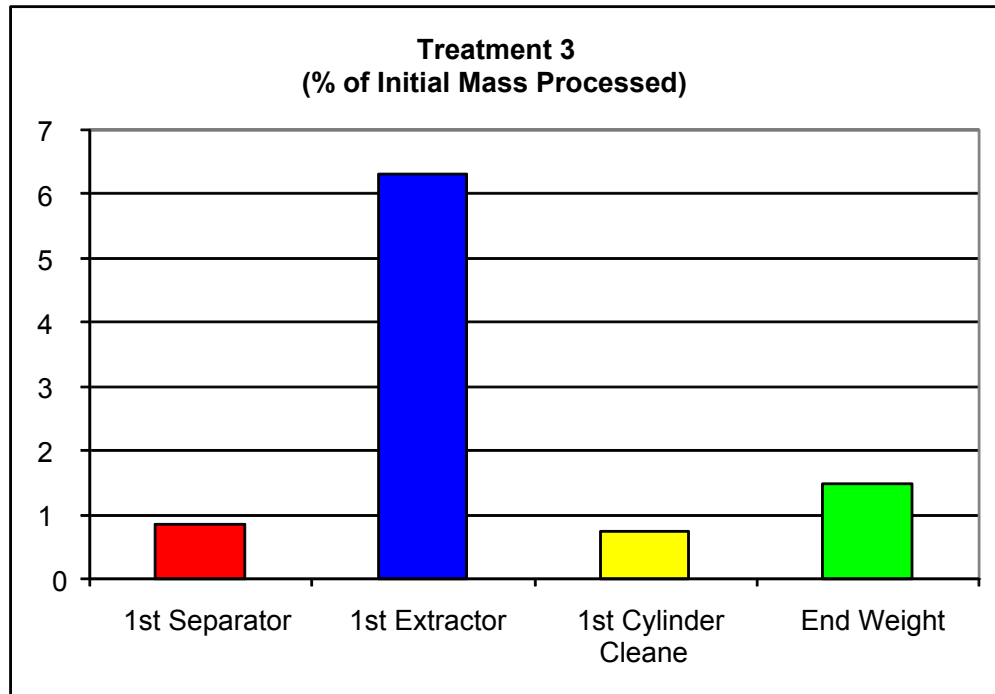


Figure 2. Bar graph of the percent of material produced from each piece of equipment used in processing the cotton gin byproducts for treatment 3. The End Weight is the percent of the original material that made it through all the processing equipment used.

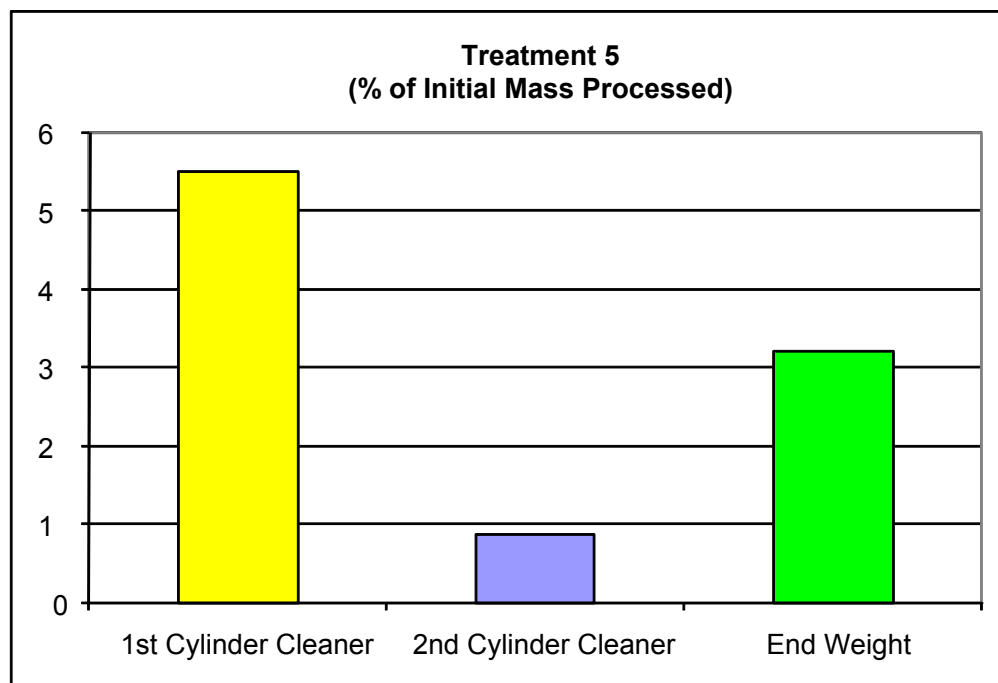


Figure 3. Bar graph of the percent of material produced from each piece of equipment used in processing the cotton gin byproducts for treatment 5. The End Weight is the percent of the original material that made it through all the processing equipment used.

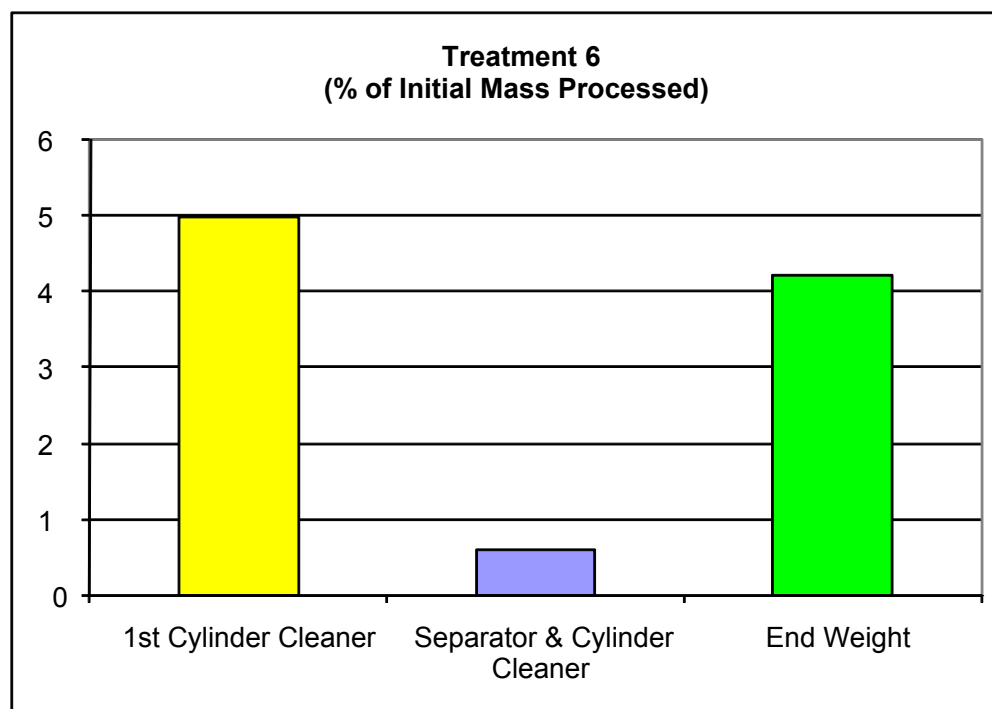


Figure 4. Bar graph of the percent of material produced from each piece of equipment used in processing the cotton gin byproducts for treatment 6. The End Weight is the percent of the original material that made it through all the processing equipment used.

of material that would be classified as “fines” (i.e. dirt, soil, and small particles of organic matter). Overall, the end weight of treatments 9 and 3 are similar with the primary difference being attributed to the second separator in treatment 9. Figures 3 and 4 show the cylinder cleaner removed more than 50 percent of the initial mass. The differences in material removed in the second stage of Figures 3 and 4 are unknown. Logically, one would think the separator and cylinder cleaner would have removed more than just the cylinder cleaner alone, 6 percent versus 9 percent, but the average shows slightly more material removed in treatment 5.

Summary and Conclusions

In an effort to address the question as to the best equipment sequencing necessary to recover the largest amount of “clean” fiber from cotton gin byproducts (gin waste), a study was conducted evaluating select combinations of separators, cylinder cleaners and extractors (stick machines). In this study, nine treatments were evaluated based upon the quantity of “clean” fiber that could be recovered from stripper harvested gin waste collected from a commercial gin in West Texas. The cotton gin, where the byproducts were obtained, baled their mote bales, so the amount of recoverable fiber should only be from lint and/or seedcotton that gets past the receiving and precleaning equipment with a very small amount being contributed from the mote press cleaning system. The “clean” fibers would be those that are suitable for going to the mote press without additional cleaning. Results showed that equipment streams using cylinder cleaners only did not produce the “clean” fibers desired compared to machinery sequences that included extractors. The machinery sequence that produced the cleanest fibers was treatment 9, which consisted of a separator, extractor, separator, and extractor. AFIS data obtained from the lint collected from each treatment indicated statistically significant differences for some of the parameters measured, but considering the fibers being recovered contained short fiber contents ranging from 23 to 30 percent by weight, the data did not indicate one machinery layout to be more important than another. After all, the fiber recovered is intended to be put into the mote bales not the lint bales and thus the statistical differences noted in the AFIS data were unimportant.

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