EVALUATION OF SELECTED GIN SAW TOOTH DESIGNS

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Abstract

Toothed saws have been used to separate cotton fiber from the seed for over 200 years. There have been many saw tooth designs developed over the years. Most of these designs were developed by trial and error. A complete and scientific analysis of tooth design has never been done. It is not known whether the optimum saw tooth design has been found, particularly for modern upland varieties. Initial laboratory ginning evaluations of some modern gin saw teeth has shown differences between designs in both ginning rate and average fiber length and length uniformity measurements. Further work remains to be done, both in the ginning laboratory and the textile mill, to document and explain these differences, and to then optimize the gin saw tooth design.

Introduction

The history of saw tooth design started with Eli Whitney's spike tooth gin patent on March 14, 1794 and Hodgen Holmes' circular toothed saw patent on May 12, 1796 (Bennett, 1960). There have been many attempts since these original patents to design the perfect gin saw tooth. The names of some of these teeth were wire teeth, sheathing wire claws, brier thorn spikes, gin saw with buckhorn needles and wire needle teeth. The impetus behind the design of these gin saw teeth is unknown and their picturesque names have faded into time and history. By 1935, saw tooth design had evolved to include a few designs that varied from about 32 to 48 degrees in pitch angle and back designs of straight, moderate roach (slightly curved back), or heavy roach (more curve) (Bennett, 1960). The curved or "roach" back designs were to give the tooth more mechanical strength than the simpler straight backed tooth. These designs probably evolved more out of practical experience as to tooth wear, some subjective evaluation of ginning rate and overall tooth life rather than organized research.

There have been some attempts at scientific evaluations of gin saw tooth designs. Martin and Stedronsky (1939) evaluated saw tooth designs, saw diameters, and numbers of teeth per saw. They found that the number of teeth, the pitch of the tooth and the tooth shape all affected ginning capacity. Griffin and McCaskill (1969) reported on a number of ginning experiments conducted at Stoneville, MS. There were several failures, but their positive conclusion was that there not be many more than 264 teeth on a 12-inch gin saw. Mayfield and McCaskill (1970) evaluated a straight back and a moderately roached back tooth design. Their primary conclusion was that the roached back tooth damaged significantly fewer seeds than did the straight back tooth. Columbus et al. (1994) make recommendations as to the maintenance and adjustments of various gin stands and their saws, but make no judgments as to differences in saw tooth design, if any, that existed between the various gin saw manufacturers. Vandergriff (1997) notes that current saw thickness varies from 0.036 to 0.045 inches, depending on the gin machinery manufacturer, and gives some of the current tooth dimensions. He notes that the pitch angle of modern 12-inch gin saws has been very nearly standardized and that there is some variation in tooth number per saw.

As Mayfield and McCaskill (1970) stated, "A complete analysis of the effects of each individual property of a saw on its performance has never been attempted. Saws have been designed at random and then their performance has been tested. Thus, no one has ever been positive that the best saw tooth design has been found". This statement is still true today. This paper reports on preliminary research looking at current gin saw tooth designs and evaluating their effects on fiber quality and ginning performance parameters.

Materials and Methods

The gin stand used for testing was a Continental Double Eagle (Continental Eagle Corp., Prattville, AL) that has been cut down to 46 saws. Four "different" sets of 16-inch diameter, commercially available replacement saws, were obtained from suppliers other than Continental, and the standard Continental saw set, were used for the five test saw sets for the ginning test. All of the saw sets were manufactured to be interchangeable for the standard 16-inch diameter Continental saws. The noticeable difference between saw sets, prior to running the test, was that the number of teeth per saw varied from 328 to 352. Each saw set was permanently stacked on a separate saw mandrel for the test and arbitrarily assigned a number from 1 to 5. The entire saw mandrel was swapped, as desired, for each of the five gin saw test conditions. Two different ginning ribs, a standard and an experimental, were used during the test, but for the purposes of this report, ginning and fiber quality results from the two different ribs were averaged together. As each set of saws was mounted in the stand, the relationship of the saw teeth leading edges to the ginning ribs was checked randomly at nine places along the saw mandrel, as recommended by Columbus et al. (1994). All five sets of test saws met the criteria for the proper relationship of saw tooth leading edge to ginning rib at the gin point.

Two different upland cottons, DPL-458 and Acala 1517-99, were used as test cottons. For the purposes of this report, the ginning and fiber property results of the two cottons were averaged together.

Testing of the five gin saws was replicated 3 times, using two different rib designs and two different cottons, resulting in a total of 60 ginning lots. Each ginning lot was processed through seed cotton cleaning using two 6-cylinder cleaners and one stick machine. No drying was used on any of the ginning lots. The seed cotton was ginned on the 46 saw gin stand, followed by one lint cleaner, and the bale press. The gin stand was operated so as to maintain the same motor horsepower for each ginning lot throughout the test. Seed cotton samples were taken at the suction pipe and the gin stand feeder apron, and ginned lint samples were taken after the gin stand and after lint cleaning for moisture, trash, and raw fiber quality analysis. The ginned lint lots were baled and sent to the USDA, ARS, Clemson Pilot Spinning Plant, Clemson, SC for further fiber analysis and textile processing. The textile processing portion of the test was not completed at the writing of this report and so this report is limited to ginning and raw fiber quality analysis only.

Results and Discussion

Most of the HVI and AFIS properties measured were not significantly affected by the saw treatments and are not reported here. Some of the measured variables of common interest that were not significantly affected are reported as a reference and to give a context for the study. Table 1 shows the average ginning rate in terms of pounds of seed cotton processed through the gin stand per minute. The ginning rates were all significantly different from each other for all 5 saw sets, and varied from a low of 66 to a high of 89 pounds of seed cotton per minute. The saw with the highest ginning rate had the fewest number of teeth. The saw with the second highest ginning rate had the same number of teeth, 352, as did the saw with the lowest ginning rate.

Table 2 shows the average nep count as measured by AFIS for each of the test saw sets. Samples of ginned fiber were taken immediately after the gin stand (before lint cleaning) and after one lint cleaner at the bale press lint slide. There were no significant differences between any of the saw sets in nep level at either location. The data show that one saw-type lint cleaner increases average AFIS nep count by over 100 counts. These data seem consistent with normal practice as to the effects of lint cleaning on nep count.

There were also no significant differences between gin saw sets in lint trash content at either lint sampling location as measured by Shirley analyzer and AFIS (Table 3). There may have been significant differences if one or more of the test saws had been breaking significantly more seed and generating excessive seed coat fragments, but this did not seem to be the case.

Significant differences between saws did occur in both HVI length and length uniformity as shown in Table 4. In general, saw sets 2, 3, and 4 resulted in the longest and most uniform fiber before the lint cleaner and this length and uniformity difference was maintained through lint cleaning. The fiber lengths from all saw treatments were reduced by lint cleaning, and uniformity differences were no longer significant after lint cleaning. The overall results indicate that there tended to be small, but significant, differences in HVI length and length uniformity due to the saw used.

Table 5 shows the average AFIS upper quartile lengths, and short fiber contents for each saw set. There were no significant differences between either of these measurements after ginning, but there were significant differences due to saw set for both upper quartile length and short fiber content after lint cleaning. Saw set 3 had the longest HVI length in Table 4 and resulted in a significantly longer upper quartile length after lint cleaning in Table 5. Saw set 3 also resulted in the lowest short fiber content after lint cleaning of any of the saw sets. Since the textile processing portion of this test is not yet completed as of this report writing, it is not known whether these short fiber, length and uniformity differences will have significant effects in yarn production.

Conclusions

From the testing done thus far on five commercially available 16-inch diameter gin saws, the following conclusions can be drawn:

1. Commercially available saws vary in number of teeth from 328 to 352, but this does not seem to influence their overall ginning performance as measured by this test.
2. Ginning rate in pounds of seed cotton ginned per unit time, at constant power, was significantly different between the saws tested. The reasons for the difference are not apparent at this time.
3. Lint nep count and trash content, before and after lint cleaning, were not significantly different among the five saw sets tested.
4. Both HVI length and length uniformity and AFIS upper quartile length and short fiber were significantly affected by saw treatments. The differences were not large and they varied, but the differences seem to be systematic and not random.
5. These results, especially ginning rate, justify further study.
6. Further analysis will be performed and conclusions will be drawn after the textile evaluation portion of this test is completed.

Disclaimer

Mention of trade names or commercial products in this publication is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture.

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Table 1. Average Gin Saw Processing Performance*

Saw Number	Number of Teeth per Saw	Pounds seed-cotton per minute
1	352	65.8 d
2	328	89.2 a
3	330	70.2 c
4	352	78.8 b
5	352	80.1 b

*Means followed by a different letter are significantly different at the 5% level by Duncan's new multiple-range test.

Table 2. Average AFIS Nep Levels*

	Nep Count, No./g	
Saw Number	Before Lint Cleaning	After Lint Cleaning
1	292	437
2	285	393
3	284	398
4	273	393
5	294	408

*No values within columns are significantly different at the 5% level as determined by Duncan's new multiple-range test.

Table 3. Average Lint Trash Content*

	Shirley Visible, %		AFIS Trash Content, lb/g	
Saw Number	Before Lint Cleaner	After Lint Cleaner	Before Lint Cleaner	After Lint Cleaner
1	7.2	2.2	171	77
2	7.0	3.0	198	127
3	7.1	2.6	187	102
4	7.4	2.9	197	117
5	6.6	2.5	185	98

*No values within columns are significantly different at the 5% level as determined by Duncan's new multiple-range test.

Table 4. Average HVI Data*

	Length, in.		Length Uniformity	
Saw Number	Before Lint Cleaner	After Lint Cleaner	Before Lint Cleaner	After Lint Cleaner
1	1.19 bc	1.14 ab	81.2 b	79.7
2	1.22 a	1.15 ab	82.3 a	80.1
3	1.19 bc	1.16 a	82.4 a	80.2
4	1.21 ab	1.15 ab	81.9 ab	79.8
5	1.18 c	1.13 b	82.1 ab	79.6

*Means followed by a different letter are significantly different at the 5% level by Duncan's new multiple-range test.

Table 5. Average AFIS Length*

	Upper Quartile Length (w), in.		Short Fiber Content (w), %	
Saw Number	**Before Lint Cleaner**	**After Lint Cleaner**	**Before Lint Cleaner**	**After Lint Cleaner**
1	1.22	1.20 ab	12.8	12.9 bc
2	1.22	1.19 b	12.0	13.8 ab
3	1.23	1.22 a	11.5	12.6 c
4	1.23	1.21 ab	11.8	13.1 bc
5	1.23	1.19 b	12.3	14.3 a

*Means followed by a different letter are significantly different at the 5% level by Duncan's new multiple-range test.