EFFECTS OF GINNING METHODS ON MECHANICAL PROPERTIES OF COTTON FIBERS

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Abstract

Effects of ginning methods on mechanical properties of cotton fibers were investigated and analyzed. The emphasis is given on the effects of ginning rate and number of lint cleaners on breaking strength and breaking elongation of single cotton fibers. Hand-ginning and machine-ginning were compared with respect to fiber tensile properties. For the preliminary experiment, three groups of cotton fiber samples were taken at the end of three different ginning rates. Both the breaking strength and breaking elongation were higher when the fibers were ginned by hand. Effects of ginning rate on breaking elongation of fiber were significant whereas the effects on breaking strength were not significant. For the main experiment, where the lint-cleaning method was considered as another process condition, the ginning rate was found to be significant for determining the tensile properties for STV 747, whereas the number of lint cleaners played an important role in determining the fiber properties for DPL 33B cotton.

Introduction

Spun yarns were produced by processing cotton fibers through numerous stages; picking cotton bolls, several stages of ginning, carding, drawing, roving and spinning as a typical example. Then the yarns were converted to knitted fabrics. Therefore, it is natural to expect that the changes in the mechanical properties of cotton fibers brought about by the machine actions during the manufacturing processes would exert indelible effects on the characteristics of the resulting textile products, namely, the fabrics and garments. However, the extent and mode of machine actions or damages inflicted upon the cotton fibers during the processes are still largely unknown.

The purpose of the present study is to evaluate changes in fiber tensile properties during the ginning process.

Materials and Methods

Cotton Samples

For the preliminary experiment, three groups of cotton fibers were taken at the end of three different ginning rates; *high*, *normal*, and *low*. The work was done at USDA Ginning Laboratory in Stoneville, MS. The ginning rates were altered by changing the ginning speed.

For the main experiment, Stonville (STV) 747 and Deltapine (DPL) 33B cottons were selected. These cottons were processed through 4 different ginning conditions; two levels of ginning rates (low and high), and two lint-cleaning methods (1 lint-cleaner and 2 lint cleaners).

MANTIS® Single Fiber Test

At least 1200 fibers were collected randomly for each ginning condition. The fibers were tested by MANTIS® single fiber tester and tensile property data were collected. The data collected were analyzed by statistical analysis programs.

Results

Preliminary Tests for the factor of ginning rates

The results of MANTIS® single fiber tensile tests are summarized in Table 1. The average breaking strength and breaking elongation are shown along with their standard deviations and ranges.

In the table, the hand-picked and hand-ginned cotton showed the highest breaking elongations and breaking strengths, and the differences between the hand-ginning and machine-ginning were statistically significant. For cotton fibers ginned at high rates, the average breaking elongation and the breaking strength were 16.98% and 5.92gf, respectively, while the same at low ginning rate were 19.20% and 5.56gf. The differences suggest that the high ginning rate significantly decreased the breaking elongation on the average. In other words, high-speed ginning could be a major cause for a reduction in the breaking elongation as well as a general reduction in the overall extensibility of cotton fibers. In examining the "normal rates," however, there was no reduction in the breaking elongation compare to the "low" rates. This could mean that there exists a threshold rate beyond which a significant reduction of breaking elongation may begin to emerge.

While the sample sizes were rather small and no replication tests were performed, the results provided strong evidence that the mechanical impacts generated by the three different ginning rates indeed lower the breaking strength, breaking elongation and the work to break.

Main Experiment

A total of 26,600 single fiber tensile tests were performed on cotton fibers, over 2800 (maximum 4000) tests per combination. Table 2 shows the experimental design and tensile properties for each combination.

From the SAS® statistical program output, several different features were observed for different varieties. Breaking strengths of STV 747 fibers were affected by all of the factors studied and their two-factor interactions. It may imply that the breaking strength of STV 747 is affected by all conditions considered. On the other hand, the number of lint cleaners did not seem to have affected the breaking elongation of the fibers.

For DPL 33B, the breaking strength was not significantly affected by the ginning rates but the interactions between ginning rates and the number of lint cleaners were significant for the breaking strength. For the breaking elongation of DPL 33B, all the factors seemed to have had significant effects. However, we need to study the pattern of the responses further in order to determine the causes.

We have performed multifactor analyses with two main factors; the effects of ginning rates and number of lint cleaners on the breaking strength and breaking elongation of each cotton variety studied.

Figures 1 – 4 show the multifactor plots of tensile properties for STV 747 cotton fibers. Based on the multifactor plots of ginning rate and lint cleaner effects, it was found that the tensile properties were enhanced with one-lint cleaner process as the ginning rates increased. However, there was no obvious improvement in the tensile properties as ginning rates increased when two-lint cleaners were applied. This fact implies that at a higher ginning rate, the tensile strength and elongation decrease as additional lint cleaner is introduced. Regardless of lint cleaners, the tensile properties in general have improved under the high ginning rate. From the above results, we could generalize that for STV 747 cotton, the ginning rate seemed to have been a critical factor in determining the tensile properties.

The same trends, however, were not shown in DPL 33B fibers. The tensile properties were not shown to have been affected by the ginning rate much. On the other hand, tensile properties were shown to have improved under the high ginning rate with one lint cleaner whereas the same was not confirmed with two lint cleaners.

Summary and Conclusions

In this study, we investigated the effects of various ginning conditions on tensile properties of two cotton varieties; STV 747 and DPL 33B. We had two process variables; ginning rate and lint cleaning methods. Before the main research, we verified that machine ginning had an adverse effect on fiber tensile properties. For the two different ginning rates, the breaking elongation was higher at the low ginning rate than that under the high ginning rate. In the main research, we also investigated the effects of the number of lint cleaners in the ginning process. For STV 747, the tensile properties obtained under the high ginning rate were better than that at the low ginning rate. With one lint cleaner, the enhancement in the tensile properties was greater than that with 2 lint cleaners especially under the higher ginning rate. For DPL 33B, however, only the effect of the number of lint cleaners was shown to be significant. The reason for this inconsistency may be attributed to their genetic differences.

Table 1. Summary Statistics for Single Fiber Tensile Properties-Obtained at Three Different Ginning Rates and from Hand-ginned Cotton.

		Machine Ginning Rate			Hand Ginning
		High	Normal	Low	
No. of Samples Tested		**2399**	**1999**	**2400**	**800**
Breaking	Mean	5.92	5.91	5.56	6.36
Strength (gf)	Std. Dev.	2.36	2.41	2.26	2.13
	Min.	0.47	0.31	0.47	0.76
	Max.	14.94	15.34	14.56	15.04
Breaking	Mean	16.98	16.89	19.20	21.11
Elongation (%)	Std. Dev.	6.97	6.86	7.50	7.24
	Min.	0.04	0.14	0.07	0.33
	Max.	43.47	54.24	47.97	49.41

Table 2. Experimental Design and Tensile Properties.

Sample ID	Ginning Rate (% of normal rate)	No. of Lint Cleaners	Avg. Breaking Strength (gf)	Avg. Breaking Elongation (%)
STV 747	75	1	6.53	19.19
		2	6.51	20.24
	125	1	6.83	21.42
		2	6.69	20.42
DPL 33B	75	1	5.63	14.90
		2	6.19	16.54
	125	1	5.79	15.92
		2	5.99	16.03

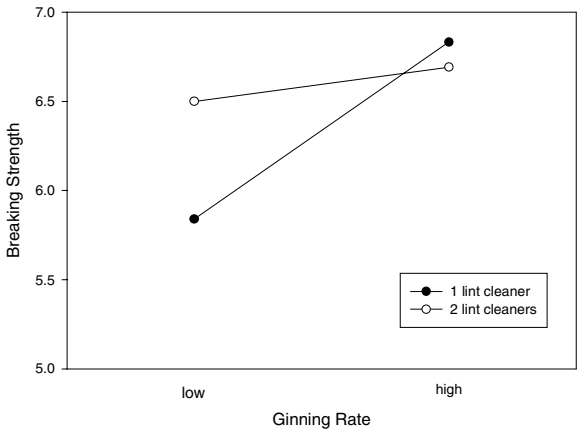

Figure 1. Ginning and Lint Cleaner Effects on Breaking Strength for STV 747 (each point represents at least 3000 samples).

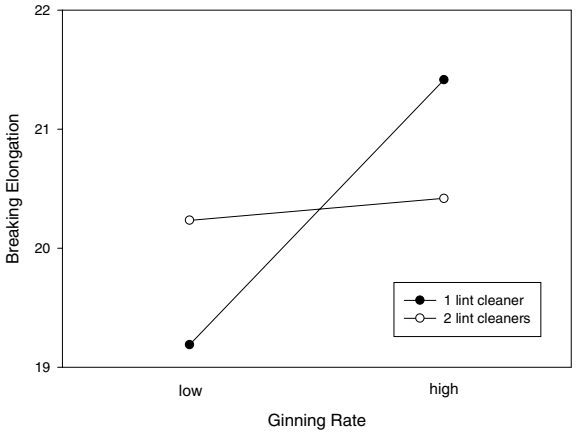

Figure 2. Ginning and Lint Cleaner Effects on Breaking Elongation for STV 747 (each point represents at least 3000 samples).

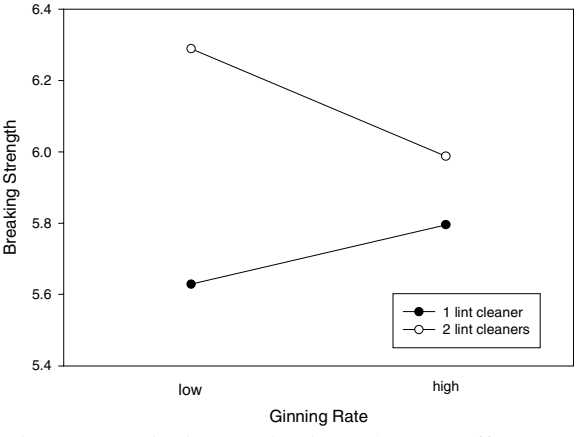

Figure 3. Ginning and Lint Cleaner Effects on Breaking Strength for DPL 33B (each point represents at least 3000 samples).

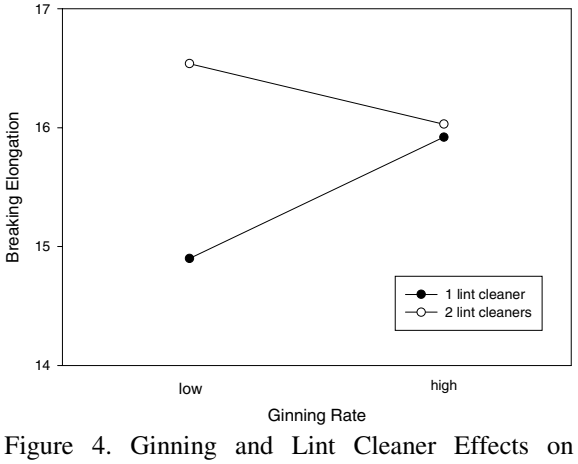

Figure 4. Ginning and Lint Cleaner Effects on Breaking Elongation for DPL 33B (each point represents at least 3000 samples).