

EFFECTS OF GINNING AND CARDING RATES ON MANTIS® SINGLE FIBER PROPERTIES OF COTTON - FROM RAW STOCK TO WASHED GARMENTS

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Abstract

This research was designed to elucidate the effects of ginning and carding rates on the cotton fiber qualities by applying two ginning rates, two lint cleaner systems, and two carding rates. The fiber samples were taken and tested with Mantis® single fiber tensile tester after ginning and carding, and before and after repeated washing/drying the T-shirts produced from the fibers. The breaking strength and the breaking elongation of single fibers were measured and analyzed statistically. Both the breaking strength and the breaking elongation decreased as the processes were compounded, and throughout the repeated washing/drying cycles. Although the magnitudes of decreases in the breaking strengths were small, the breaking elongations were shown to have decreased substantially between carding and washing/drying. After carding, the fibers processed at a higher ginning rate exhibited somewhat greater breaking strengths and breaking elongations.

Introduction

The ginning and carding processes are designed to enhance the uniformity and orientation of the fibers in addition to removing trashes and foreign matters required for the production of spun yarns. However, these processes also are known to damage the fibers during the processing and lower the quality of the fibers. While the qualities of the resulting yarns, fabrics, and garments are adversely affected by various processing conditions, the extent of the damage, with regard to the fiber properties, has not been well quantified by scientific means.

This research was designed to elucidate the effects of ginning and carding processes on the resulting fiber qualities by applying two ginning rates, two lint cleaner systems, and two carding rates. In this research, we measured tensile properties of individual fibers from raw stocks, ginned cotton, card slivers, and the unwashed and washed T-shirts produced from the fibers. We studied the effects of various ginning and carding conditions on the tensile properties, and the changes of the properties as the processes continued up to garment manufacturing, and after 32 cycles of repeated washing/drying. The research was aimed at obtaining some insight as to how the fiber qualities change by ginning and carding, and how the changes might continuously affect the fiber properties during spinning, knitting, and within garments when they were subjected to repeated washing and drying.

Materials and Methods

Ginning and Carding Conditions

Two cotton varieties, Stoneville (STV) 747 and Delta Pine 33B, were selected. These cottons were processed under 8 different processing conditions; two levels of ginning rates (75% and 125% of normal ginning rate), two lint cleaning methods (1 and 2 lint cleaners), and two levels of carding rates (60 lbs./hr and 120 lbs./hr). The cotton samples were ginned at USDA ginning laboratory, Stoneville, MS. These cottons were shipped to USDA-ARS Clemson Laboratory for carding and spinning.

After carding, card slivers were processed by an RS 951 draw frame without auto-leveler and then by an RS 351, a draw frame with auto-leveler, to produce 0.75 hank rovings with a 1.30 TM. Details of the experimental scheme are shown in Table 1.

Spinning, Knitting, and T-Shirt Manufacturing

Each cotton variety was processed to produce 20/1 Ne ring spun yarns with a Sinzer 321 Ring-spinning machine at spindle speed of 14,000 rpm. The yarns were knitted into 1×1 plain jersey fabrics, and they were washed and scoured to produce T-shirts.

Repeated Washing and Drying

We used automatic a commercial washer and tumble-dryer satisfying the recommended AATCC method. Each garment was considered to be a test specimen. Shrinkages were checked for three T-shirts for each treatment combination in order to increase the precision of the average. Prior to the measurements, pre-conditioning was done as directed by ASTM D 1776.

T-shirts were placed separately under the standard condition ($70 \pm 2^\circ\text{F}$ and $65 \pm 2\%$ RH) for at least 24 hours. In order to eliminate any possible effects from different washers and dryers, we used one washer and one dryer. After filling the washer with water to the specified volume, we placed 16 T-shirt samples in the washer. Each washing and drying load consisted of 6.2 lbs. of dry fabric equivalent, and the washing was done without ballast. In our experiment, we selected normal machine cycles, water temperature of $120 \pm 5^\circ\text{F}$, and normal tumble-dry cycles. Each washing cycle was approximately 30 minutes with the rinse temperature set at 85°F . The T-shirts were moved to the dryer immediately after the final washing cycle. At the end of washing and drying cycles, the garments were conditioned under the standard atmospheric condition, namely, $70 \pm 2^\circ\text{F}$ and $65 \pm 2\%$ RH for 24 hours.

MANTIS® Single Fiber Test

A total of 11,600 single fiber tensile tests were performed on cotton fibers sampled from card slivers and T-shirts. Over 1,600 (maximum 2,000) tests were performed on each treatment combination. The tensile properties obtained from MANTIS® single fiber tester were analyzed statistically by SAS® statistical package. For comparison, 1,200 single fiber tests were performed for the fibers unraveled from the unwashed T-shirt that showed the highest amount of shrinkage.

Results and Discussions

Changes in Single Fiber Tensile Properties from Raw Stock to Washed Garments

Cotton fibers were sampled to obtain the single fiber tensile data at each stage of processing; raw stock, ginned cotton, card sliver, unwashed T-shirt, and washed T-shirt.

Figures 1–2 show the average breaking strengths and breaking elongations of single fibers at these stages. Both the breaking strength and the breaking elongation decreased as the processes progress, with an exception in carding. The cotton samples obtained at ginning were not fully opened and mixed, lacking the uniformity to represent the entire cotton stock by testing only a few thousand single fibers. While we obtained the results and reported, the margin of error is considered very wide. Therefore, we focused only on the tensile properties from card slivers, unwashed T-shirts, and washed T-shirts in drawing the main conclusions.

The Effects of Ginning and Carding on the Single Fiber Breaking Strength

Figures 3 – 5 show the effects of ginning rates, number of lint cleaners, and carding rates on the breaking strength of fibers. Fibers from card slivers processed at the higher ginning rate showed a higher average breaking strength than that at the low ginning rate. However, the average strengths of the fibers unraveled from unwashed and washed T-shirts were shown to be higher for the fibers processed at the low ginning rate. In other words, the effects of ginning rate were inverted between carding and knitting processes. Since cottons were processed under exactly the same conditions except ginning and carding, we may conclude that the hidden effects of ginning and carding finally emerge perhaps only when the garments are washed and dried, that is, after the fibers are fully relaxed. Throughout the entire processing stages, fibers processed with one lint cleaner showed higher breaking strengths than processed with two lint cleaners. Likewise, the lower carding rate produced higher breaking strengths throughout the entire processing stages.

In addition, the decrease in the average breaking strength was shown to be progressive as the number of repeated washing/drying cycles increases. It indicates that the repeated washing/drying of garment resulted in significant damages in the tensile properties of the fibers.

The Effects of Ginning and Carding on the Single Fiber Breaking Elongation

Figures 6 – 8 show the effects of ginning rates, number of lint cleaners, and carding rates on the breaking elongation of fibers. Unlike the case for the breaking strength, there were no significant effects of ginning or carding rates on the breaking elongations. However, regardless of the ginning and carding effects, the decrease in breaking elongation was conspicuous as the processing continued. It was shown that the decrease in breaking elongation was quite substantial between carding and washing/drying trials, implying that the degradation during finishing (before garment production) was highly significant.

Discussions and Rationalization

It was expected that higher processing rates and excessive cleaning would damage fibers and lower the qualities as measured by their tensile properties. This was confirmed in washed and unwashed T-shirts. However, the fibers from card slivers did not show a negative effect of higher ginning rate with any consistency. As already alluded, it may be that the effects of dry processing are hidden and stored within the fibers but are revealed when the fibers are scoured, washed and dried repeatedly.

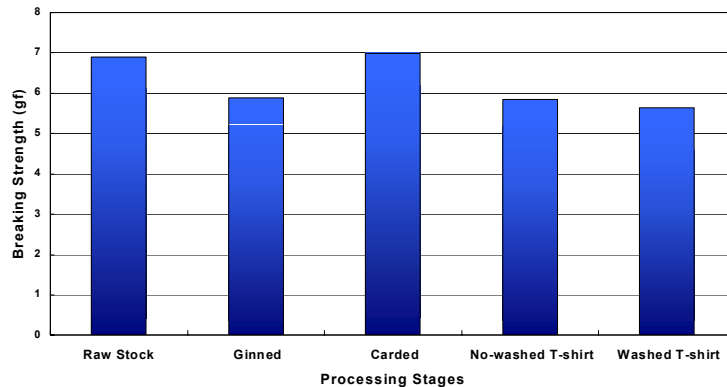
Although the breaking strength continuously decreased throughout the processes, it is very important to note that the decrease in the breaking elongation was substantial from card slivers to T-shirts before washing/drying. This may indicate that the fibers lose much of their elasticity during spinning and knitting and show the loss during the first wet processing stage, namely, the scouring and washing for garment production.

References

Suh, M. W. and S. J. Doh *Effects of Ginning and Carding Rates on Yarn and HVI Bundle Tensile Properties of Cotton*, Proceedings of 2004 Beltwide Cotton Conference, January 8 – 9, 2004, San Antonio, TX.

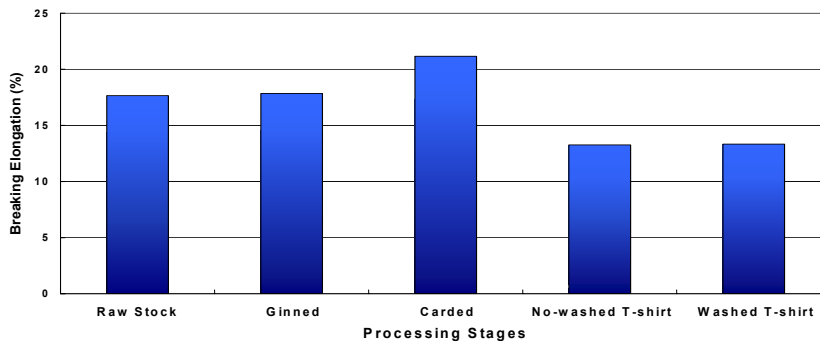
Table 1. Details of Experimental Scheme - Opening, Carding and Spinning.

Line Used in Opening and Carding	Truetzschler Opening Line and DK 740 Card
Sliver Produced	70 gr. Sliver
Carding Rate	60 lbs./hr and 120 lbs./hr
Card Mat Testing	Collect ½ lb. sample. Record beginning wt, sliver wt, and waste at each cleaning point.
Shirley Analyzer	Save all wastes for Shirley Analyzer.
Evenness Test	Carry out the test on card sliver and save the samples for AFIS tests.
1st Drawing	60 gr. sliver 6 ends up
2nd Drawing	61 gr. sliver 8 ends up Do an evenness test on the finisher drawing sliver and save samples.
Roving	Produce .75 Hank with a 1.30 TM
Spinning Ring	The lots were run on the ring spinning frame. Spin the entire cotton into 20/1's yarn at 14,000 spindle speed, 3.85 TM. Record ends-down for the entire tests. Perform Cassimat tests on each lot and then send all yarns to testing lab.



* Data for fibers processed at high ginning, 1 lint cleaner, and high carding rate.

Figure 1. Breaking Strength* vs. Processing Stages.



** Data for fibers processed at high ginning, 1 lint cleaner, and high carding rate.

Figure 2. Breaking Elongation** vs. Processing Stages.

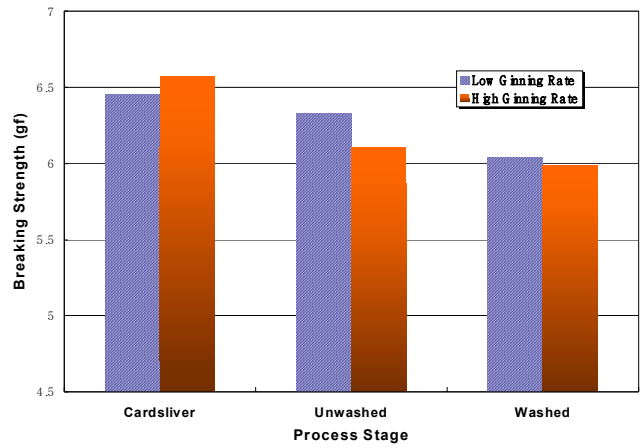


Figure 3. Breaking Strength vs. Ginning Rates.

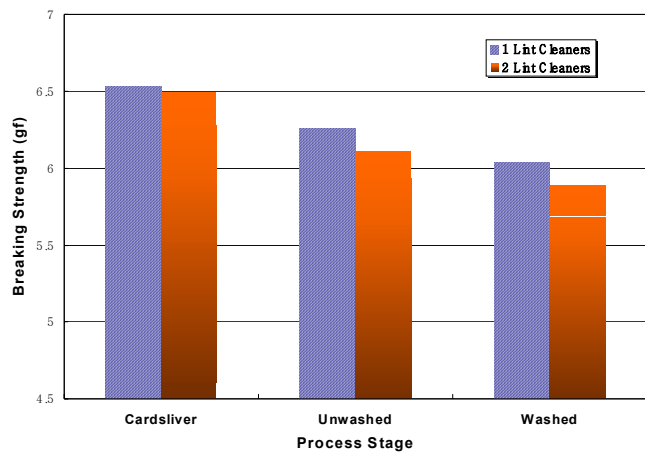


Figure 4. Breaking Strength vs. Number of Lint Cleaners.

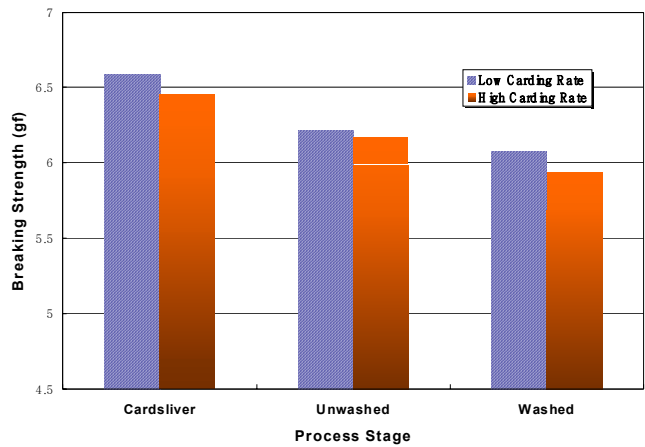


Figure 5. Breaking Strength vs. Carding Rates.

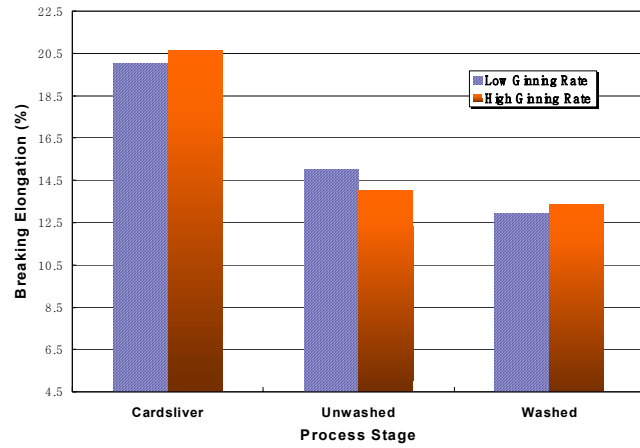


Figure 6. Breaking Elongation vs. Ginning Rates

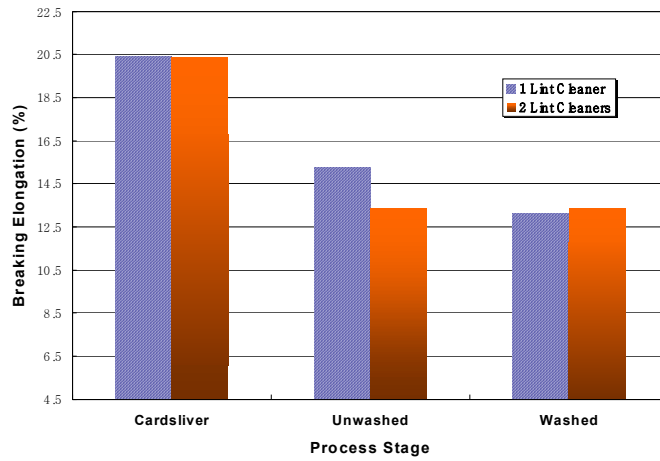


Figure 7. Breaking Elongation vs. Number of Lint Cleaners.

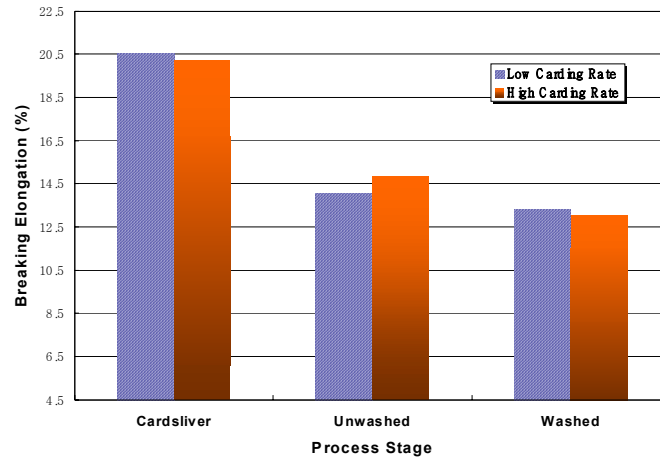


Figure 8. Breaking Elongation vs. Carding Rates.