2002 BELTWIDE COTTON CONFERENCES, ATLANTA, GA – JANUARY 8-12

EFFECTS OF GINNING AND CARDING RATES ON THE TENSILE PROPERTIES OF COTTON FIBERS AND SPUN YARNS

Moon W. Suh and Song Jun Doh
College of Textiles
North Carolina State University
Raleigh, NC
Michael D. Watson
Cotton Incorporated
Cary, NC
David McAlister
USDA-ARS Laboratory
Clemson, SC

Abstract

The early stages of cotton spinning process are designed to enhance fiber uniformity and degree of orientation in addition to removing trashes and foreign matters for the production of yarn. Unfortunately, these processes also 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 has not been well quantified by scientific means. This research was designed to elucidate the effects of ginning and carding processes on the yarn quality by applying two ginning rates, two lint cleaner systems, and two carding rates. Tensile properties of fibers and spun yarns produced under the different processing conditions were measured and analyzed by single factor and multifactor analyses. As the ginning rate increased, fiber breaking strengths for both STV 747 and DPL 33B cottons were shown to have improved. For DPL 33B cotton, the breaking strengths of the yarn were shown to be high when processed with one lint cleaner and under low carding rate. In addition, the ginning rate was also an insignificant factor. Only the number of lint cleaners affected the breaking elongation of the yarns.

Introduction

Although studies were made extensively on tensile properties of cotton fibers in bundle forms in the past, little research has been conducted as single fibers. 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 fabrics and garments. However, the modes and extents of machine actions or damages inflicted upon the cotton fiber during ginning and the subsequent processes are too numerous and complex, and often indeterminate, to be amenable to be quantified or identified. Investigations on this important issue was not possible simply due to lack of means for testing the tensile properties of a sufficiently large number of cotton fibers before and after each stage of processing. Yet, it is readily conceivable that the rapid and repeated loading of cotton fibers may leave irreversible effects on cotton fibers.

Loss of the fiber's "liveliness" for instance, through impairment of its elasticity, may be reflected in terms of certain latent changes in the stress-strain behavior of fibers, yarns and fabrics. More importantly, how these changes are manifested during the lifetime of a product is of great interest and significance.

As a part of larger research, we investigated the effects of ginning and carding on cotton fibers and the qualities of the resulting spun yarns.

Materials and Methods

Ginning and Carding Conditions

Stoneville (STV) 747 and Deltapine (DPL) 33B cottons were selected. These cottons were processed through 8 different processing conditions; two levels of ginning rates (75% and 125% of normal ginning rate), two lint-cleaning methods (1 lint-cleaner and 2 lint cleaners), and two levels of carding rates (60 lbs./hr and 120 lbs./hr).

Spinning Conditions

After drawing and roving, each group of cottons was processed to produce 20/1 Ne ring spun yarns with Sinzer 321 Ring-spinning machine with a spindle speed of 14,000 rpm. Tensile testing were performed through Statimat® yarn tensile tester.

MANTIS® Single Fiber Test

A total of 26,600 single fiber tensile tests were performed on cotton fibers sampled after the carding process. Over 1200 (maximum 2000) tests were performed on each treatment combination. MANTIS® single fiber tester tested the fibers and tensile property data were collected and analyzed using SAS® statistical procedures.

Results

Fiber Tensile Properties

The average breaking strength and breaking elongation for each processing condition were shown in Table 1. Figures 1 to 3 show the effects of each processing variable on fiber breaking strengths for both varieties. Figure 1 shows the effects of ginning rates on breaking strength for both varieties. As ginning rate increased, breaking strength of STV 747 increased significantly, while the increase for DPL 33B was insignificant. The breaking strengths with respect to the number of lint cleaners are shown in Figure 2. The breaking strength of STV 747 decreased as the number of lint cleaners increased. However, the breaking strength of DPL 33B increased with 2 lint cleaners. Figure 3 shows the effects of carding rates on breaking strength. At the higher carding rate, the breaking strength of STV 747 cotton increased while a decrease was shown for DPL 33B. Figures 4 to 6 show the effects of each processing variable on fiber breaking elongations for both varieties. As ginning rate increased, breaking elongation for STV 747 increased significantly whereas the change was insignificant for DPL 33B. The effects of the number of lint cleaners and carding rates on breaking elongation seem to be insignificant for both varieties.

Multifactor analyses were also performed on the three main factors; the effects of ginning rates, number of lint cleaners, and carding rates on the breaking strength and breaking elongation of each variety. Based on the analyses, it was found that the ginning rates played the most important role in determining the fiber breaking strength.

Yarn Tensile Properties

We obtained yarn tensile data and evenness data from a Statimat® at the USDA-ARS Clemson Laboratory. The results are shown in Table 2.

DPL 33B Cotton

Figures 7(a) and 7(b) show that the yarn strength is shown to be higher under the higher ginning rate than the low ginning rate by 0.1 - 0.2 g/tex. The yarn strengths were seemingly lower under the two-lint cleaner ginning process than the one-lint cleaner process by 0.35 – 0.4 g/tex (Figures 7(a) and 7(c)). The effects of carding rate were negatively correlated with the breaking strength (Figures 7(b) and 7(c)). In other words, the breaking strength of the yarn under the high carding rate was lower than obtained under the low carding rate. Even though the differences were not highly significant, this may imply that these two factors play a significant role in determining the yarn strength.

The multifactor plots for the breaking elongation of the yarns are shown in 7(d)-7(f). When an additional lint cleaner was used, the yarn breaking elongation seems to have decreased by about 0.4%. Carding rate, however, did not seem to have affected on the breaking elongation much.

STV 747 Cotton

Figures 8(a), 8(b), and 8(c) show the multifactor plots of yarn strengths based on two factors at a time. The effects of ginning rate and the number of lint cleaners were complex in determining the breaking strength of the spun yarns. The ginning rates and the number of lint cleaners had significant interaction; with one-lint cleaner, the breaking strength decreased as the ginning rate increased whereas the strength of the yarn increased with two-lint cleaners. When the carding rate was high, the breaking strengths were higher than that obtained under low carding rate at the low ginning rate process. However, the difference diminished at the high ginning rate process. The breaking elongation of the yarns showed no definite trends (Figures 8(d) - 8(e)).

Summary and Conclusions

For both STV 747 and DPL 33B cottons, the ginning rate was the most critical factor for determining breaking strength and breaking elongation. The tensile properties increased with the ginning rate for both varieties. The responses to the effect of the number of lint cleaners and the carding rates, however, were somewhat complex. This inconsistency seems to be due to the intrinsic properties specific to cotton varieties.

For DPL 33B cotton, application of one lint cleaner and low carding rate improved the yarn strength. The ginning rate, however, did not have significant effects on the breaking strength. The breaking elongation decreased when an additional lint cleaner was used in the ginning process. As the ginning rate increased, a slight increase was observed in the breaking elongation.

For STV 747 cotton, the effects of carding rate on breaking strength was negligible at the high ginning rate and the two-lint cleaner process. For the breaking elongation, there were interactions among the factors were highly significant and complex.

While some of the effects studied are important but somewhat inconsistent, the ultimate goal of this research has been to evaluate the fiber properties to be exhibited in fabric and garment forms. Thus, the results reported in this study are to be useful for interpretation of the tests to be conducted in the future. For this reason, the results from fiber and yarn tests should not be construed to be the general conclusions on the effects of certain ginning and carding processes on cotton fiber properties.

Table 1. Experimental design and fiber tensile properties.

Sample ID	Ginning Rate (% of normal)	No. of Lint Cleaner	Carding Rate (lbs./hr)	Denotation	Breaking Strength (gf)	Breaking Elongation(%)
STV 747	75	1	60	$S\_G_1L_1C_1$	6.62	19.38
			120	$S\_G_1L_1C_2$	6.46	19.05
		2	60	$S\_G_1L_2C_1$	6.62	20.46
			120	$S\_G_1L_2C_2$	6.39	20.01
	125	1	60	$S\_G_2L_1C_1$	6.67	21.67
			120	$S\_G_2L_1C_2$	6.99	21.16
		2	60	$S\_G_2L_2C_1$	6.92	20.11
			120	$S\_G_2L_2C_2$	6.41	20.81
DPL 33B	75	1	60	$D\_G_1L_1C_1$	5.54	14.43
			120	$D\_G_1L_1C_2$	5.72	15.37
		2	60	$D\_G_1L_2C_1$	5.91	15.67
			120	$D\_G_1L_2C_2$	5.91	15.67
	125	1	60	$D\_G_2L_1C_1$	5.76	15.07
			120	$D\_G_2L_1C_2$	5.82	16.6
		2	60	$D\_G_2L_2C_1$	5.95	16.11
			120	$D\_G_2L_2C_2$	6.02	15.95

Table 2. Yarn Tensile Data and Evenness Data gone through Various Conditions.

Samples	Yarn Strength (g/tex)	Yarn Elongation (%)
$S\_G_1L_1C_1$	15.77	7.47
$S\_G_1L_1C_2$	16.27	7.39
$S\_G_1L_2C_1$	15.81	7.06
$S\_G_1L_2C_2$	15.98	7.64
$S\_G_2L_1C_1$	15.76	7.57
$S\_G_2L_1C_2$	15.82	6.88
$S\_G_2L_2C_1$	16.14	7.66
$S\_G_2L_2C_2$	15.99	7.26
$D\_G_1L_1C_1$	16.67	6.54
$D\_G_1L_1C_2$	16.51	6.49
$D\_G_1L_2C_1$	16.58	6.16
$D\_G_1L_2C_2$	15.92	6.13
$D\_G_2L_1C_1$	17.12	6.89
$D\_G_2L_1C_2$	16.50	6.63
$D\_G_2L_2C_1$	16.39	6.24
$D\_G_2L_2C_2$	16.37	6.70

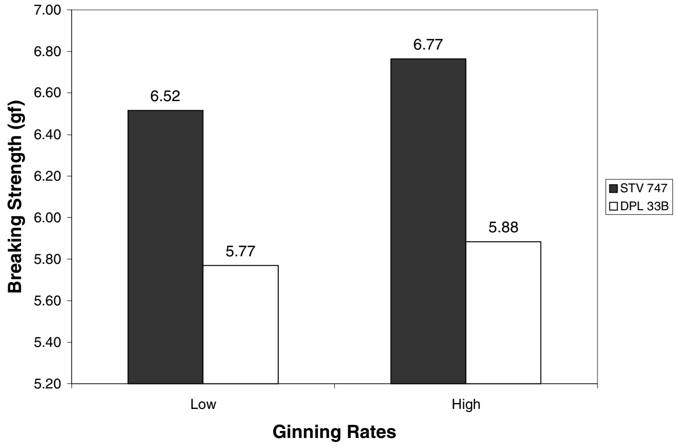


Figure 1. Ginning rates vs. fiber breaking strength for STV 747 and DPL 33B (each bar represents +6000 tests).

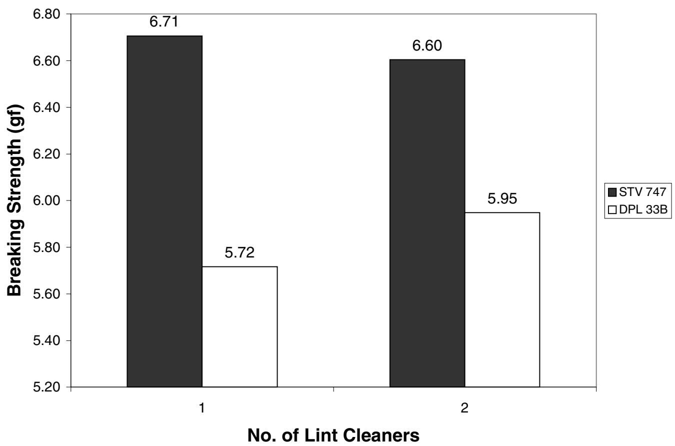


Figure 2. No. of lint cleaners vs. fiber breaking strength for STV 747 and DPL 33B (each bar represents +6000 tests).

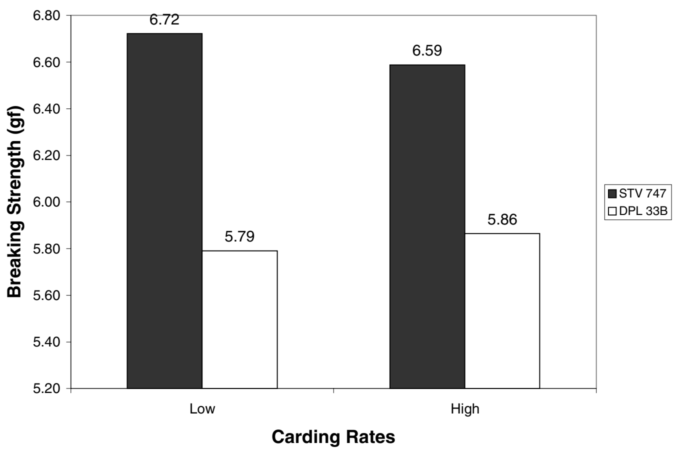


Figure 3. Carding rates vs. fiber breaking strength for STV 747 and DPL 33B (each bar represents +6000 tests)

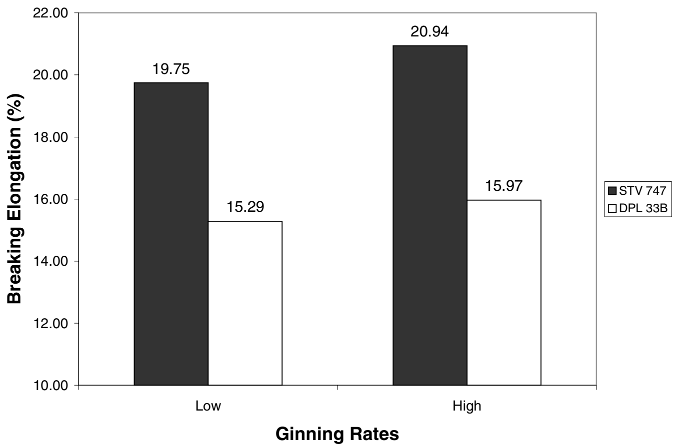


Figure 4. Ginning rates vs. fiber breaking elongation for STV 747 and DPL 33B (each bar represents +6000 tests).

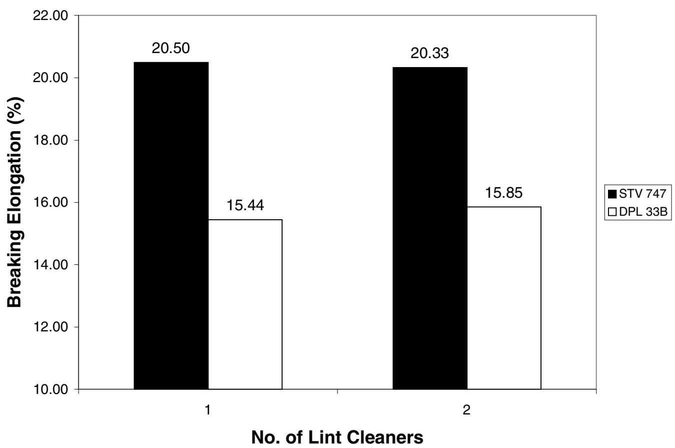


Figure 5. No. of lint cleaners vs. fiber breaking elongation for STV 747 and DPL 33B (each bar represents +6000 tests).

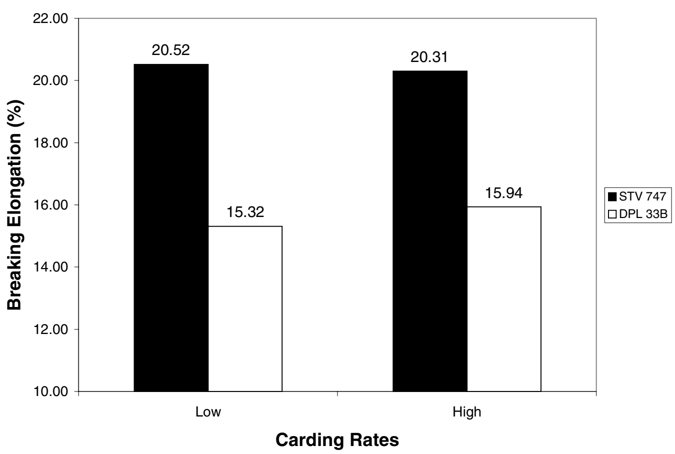


Figure 6. Carding rates vs. fiber breaking elongation for STV 747 and DPL 33B (each bar represents +6000 tests)

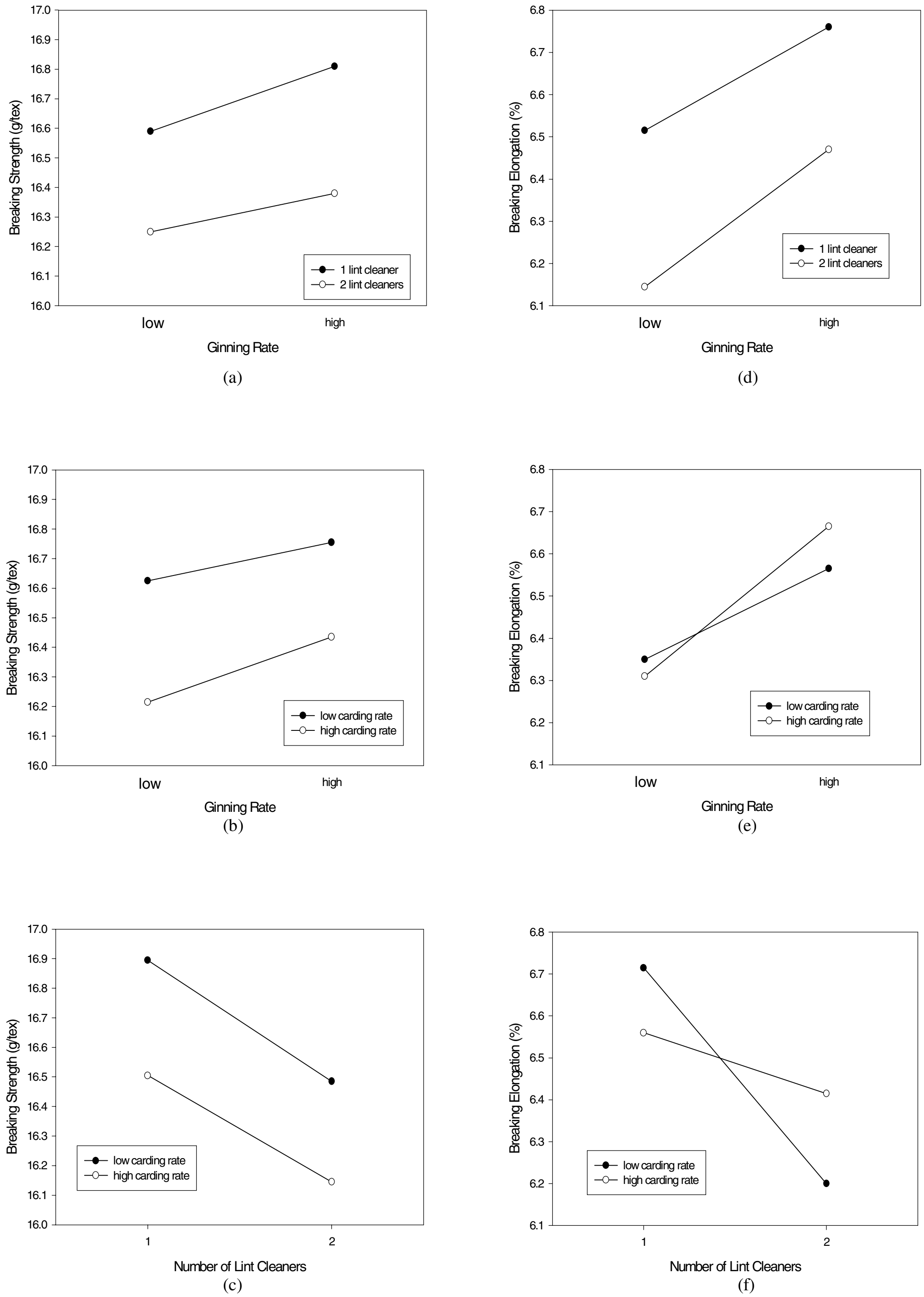
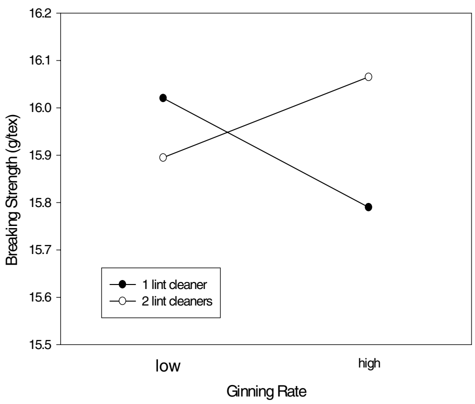
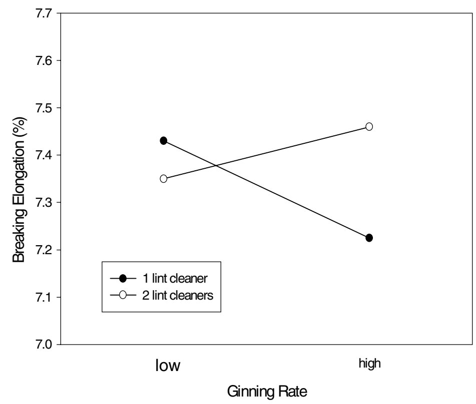


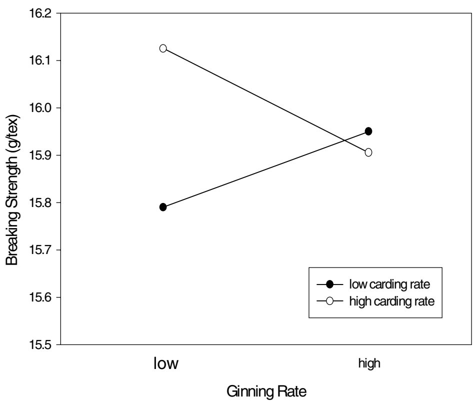
Figure 7. Multifactor Plots of DPL 33B Tensile Properties by Various Process Conditions; (a)-(c): breaking strength, (d)-(f): breaking elongation



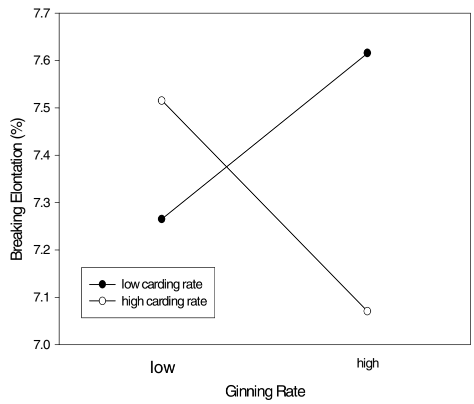
(a)



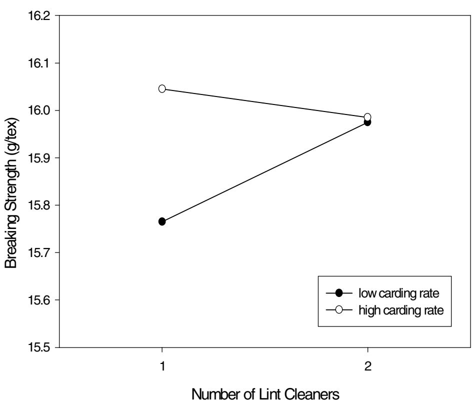
(d)



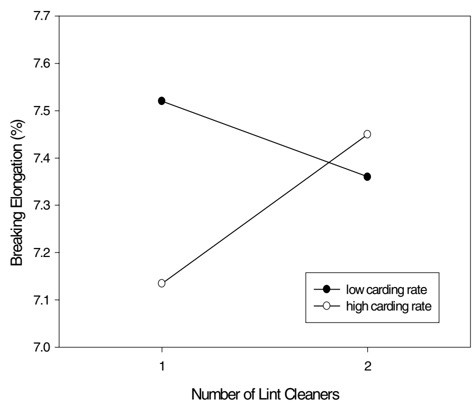
(b)



(e)



(c)



(f)

Figure 8. Multifactor Plots of STV 747 Tensile Properties by Various Process Conditions; (a)-(c): breaking strength, (d)-(f): breaking elongation