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Influence of Some Mechanical Factors of Ring Spinning Machine on Cotton Yarn Quality

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Abstract: 30^S carded cotton yarn strength and irregularity was studied by changing the twist multiplier and spindle speed of ring machine during its manufacturing. The best results of yarn lea strength and evenness were obtained at the lowest spindle speed SP_1 and twist multiplier TM_1.

Keywords: Ring Spinning, Cotton Yarn Strength, Spindle Speed and Yarn Strength

Introduction

Yarn quality parameters are influenced remarkably by the raw material as well as machine factors. There is a direct relationship between yarn strength and fibre bundle strength; same is the case with yarn irregularity and imperfections, though imperfections are deeply concerned with short fibre index, fibre maturity and micronaire value, along with the machinery conditions in back process and other processing and climatic conditions.

Higher spindle speed is responsible for developing greater yarn tension and more fibre slippage in the strand. No doubt, an increase in spindle speed for a certain count boosts up the yarn production but quality deterioration at extraordinarily high speed is unavoidable.

The amount of twist to be implied in any yarn usually depends upon staple length, count or yarn number and the use for which the yarn is intended. As yarn twist increased, the angle of inclination increased and therefore the component of fibre strength in the direction of yarn axis decreases. The frictional resistance among the fibers also gradually increases until a point is reached at which slippage is virtually eliminated, beyond that optimum point the fibre rupture may occur, certainly, causing an increase in CV% of strength and yarn irregularity. The present study was suggested to examine the effect of spindle speed and twist factor on the ultimate yarn quality.

Materials and Methods

The present investigations were initiated in the Department of Fibre Technology, University of Agriculture, Faisalabad and conducted mainly in Resham Textile Industries, Chunian Road, Habibabad (Distt. Kasur) during the year 2000.

Before processing, the raw cotton samples were collected from the running stock and were subjected to the following tests of the fibre characteristics according to the standard techniques as suggested by ASTM Committee (1997).

A: Fibre Physical Characteristics

- Staple length at 2.5 span length. (ASTM Committee 1997)
- Length uniformity ratio. (ASTM Committee 1997)
- Micronaire value. (ASTM Committee 1997a)
- Fibre bundle strength. (ASTM Committee 1997b)
- Maturity percentage. (Farooqi *et al.* 1972)

B: Roving samples were produced in a routine process of spinning without any technical change in the back process machinery, keeping the hank roving as 1.27.

C: Yarn count of 30^s carded was prepared at different levels of spindle speed and twist multiplier, keeping all other factors constant.

Spindle speed levels	Twist Multipliers
SP_1 = 15600 r.p.m.	TM_1 = 4.1
SP_2 = 16400 r.p.m.	TM_1 = 4.4
SP_3 = 17200 r.p.m.	TM_1 = 4.7
SP_4 = 18000 r.p.m.	

Yarn Characteristics: Yarn samples prepared at each set of above changes were tested for the following important quality characteristics.

Yarn Number: Yarn number was estimated through `Skein Method' by ASTM Committee (1997c) on "Digital Uster Autosorter III which gives direct reading of yarn number, range and CV% of count, etc.

Yarn Lea Strength: Lea strength of each yarn sample was determined on pendulum type tensile tester by `Skein Method' as approved by ASTM Committee (1997d).

Yarn Evenness (U%): yarn evenness or U% was tested on Uster Tester III, according to the procedure suggested by M/S Zellweger Uster Ltd. Switzerland in its operational manual.

Statistical Analysis: The data was analyzed statistically by applying Completely Randomized Design (CRD) with two factorial as suggested by Steel and Torrie (1984). Duncan's Multiple Range (DMR) test was applied for individual comparison of mean values.

Results and Discussion

The focus of present study is to examine the influence of change in ring spindle speed and twist multiplier on yarn lea strength and evenness. Therefore, the results about these two quality parameters are discussed in Table 2 and 3 whereas Table 1 illustrates the fibre properties as under:

- Fibre staple length at 2.5 span length ranging from 26.97 to 27.79 with an average as 27.18 mm
- Fibre bundle strength ranged from 88.75 to 92.00 thousand pounds per square inch with the mean value as 90.27 thousand pounds per square inch
- Length uniformity ratio ranged 49.00 to 50.85% with a mean value of 49.81
- The average value of fibre maturity was noted as 85.53%

Yarn Characteristics

Yarn Number: The results pertaining to yarn count 30^s

carded samples obtained at different sets of spindle speeds, twist multipliers and their interaction are shown in Table 2. All the results are found highly significant.

The analysis revealed that the best value of yarn number nearest to the nominal value was found at spindle speed SP_2 = 16400, whereas at SP_3 and SP_4 the count became finer and coefficient of variation percentage of count also increased. This result was confirmed by the findings of Grover and Hamby (1966) who reported that higher spindle speeds when exercised in ring spinning resulted in the count variation.

In case of change in twist multiplier, Duncan's Multiple Range Test for individual comparison of mean values for count revealed that TM_2 is the best setting for optimum value of yarn number with respect to the nominal value. The result of interaction SP_1 x TM was the best one which illustrated that at lower spindle speed with lower TM value, the less count was produced. The present findings are confirmed by Iqbal (1992) who reported highly significant effect of spindle speed and twist multiplier on yarn count.

Lea Strength: Table 3 shows the analysis of variance of the data relating to lea strength for 30^s carded at different spindle speeds and Twist multipliers, as well as their interactions.

Lea strength for 30^s carded yarns, spun at different levels of spindle speeds i.e. SP_1, SP_2, SP_3 and SP_4 are found as 78.48, 76.30, 75.38 and 73.69 lbs., indicating that SP_1 = 15600 rpm is the best level of spindle speed for optimum lea strength. It is, therefore, concluded that maximum spindle speed produced the strongest yarn. Previously, Iqbal (1992) and Abbasi (1994) also recorded the highly significant effect of spindle speed on yarn lea strength.

The analysis of the data regarding lea strength of the 30^s carded yarn prepared at different levels of twist multipliers, i.e. TM_1, TM_2 and TM_3 revealed the mean values as 74.72, 78.26 and 74.90 pounds respectively. The maximum yarn strength was observed at the twist multiplier TM_2, while it decreased on further increase in twist. The present results are confirmed by the previous research work of different scientists for example, the results in hand are in quite conformity with the findings of Goodwin (1959) who concluded that an increase in twist had direct effect on yarn strength.

Moreover, Booth (1983) reported that an increase in the amount of twist strengthened the yarn. Upto a certain point, addition in twist causes an increase in the yarn strength, however, beyond that point further twist insertion causes a decrease in the strength. This maximum twist at optimum level is called as optimum twist. Further it is noted that the interaction SP_1 x TM_2 is the best suitable interaction for optimum lea strength of 80.87 lbs. for 30^s carded.

Yarn Irregularity (U%): Table 4 illustrates the highly significant effect of spindle speed levels, twist multipliers on yarn irregularity percentage. The average U% values for 30^s carded recorded at spindle speeds SP_1, SP_2, SP_3 and SP_4 as 11.95, 12.21, 12.09 and 12.32 percent respectively. The best lowest mean value of U percentage was obtained at SP_1 as 11.95 percent, whereas, the irregularity increased significantly on increasing the spindle speed gradually showing the highest value of irregularity in the present trials at SP_4 for 30^s carded. These results are at par with the findings of Iqbal (1992) and Abbasi (1994) who reported about the highly significant effect of spindle speed and twist multiplier.

In case of changing in twist multiplier the lowest mean value or U% i.e. 11.97% was noted at TM_1 where as TM_3 gave the irregularity percentage of 12.39 as maximum, illustrating obviously that significant increase in U% occurs at higher twist factor. The present findings are found similar to the work of Simpson and Fiori (1975) who reported that yarn uniformity improved and imperfections decreased when twist amount is decreased. In case of spindle speed and twist multiplier interaction, the best value of U% for 30^s carded was found at the interaction SP_1 x TM_1).

Table 1: Physical Characters of Cotton Variety MNH-93.

Sr. No	.Fibre Staple length (mm)	Fibre Strength 000/lbs/sq.in.	U.R%	Fibre Fineness µg/inch	Fibre Maturity %
1	27.00	89.60	49.56	4.50	85.41
2	27.53	90.70	50.10	4.75	84.23
3	27.27	89.90	50.85	4.65	86.11
4	26.97	91.10	49.05	4.45	84.79
5	27.79	88.75	50.10	4.50	84.74
6	27.15	92.00	50.30	4.40	85.51
7	27.60	89.20	49.00	4.50	87.10
8	27.12	91.50	49.50	4.75	85.32
9	27.20	89.80	50.15	4.55	86.25
10	27.20	90.37	49.45	4.40	85.89
X	27.18	90.27	49.81	4.54	85.53
S.D.	0.24	1.03	0.58	0.13	0.84
C.V.%	0.90	1.14	1.18	2.86	0.98

X = Mean Value
S.D. = Standard Deviation
C.V.% = Count Variation%

Table 2: Analysis of Variance for Yarn Number 30^s Carded

S.O.V	d.f	S.S	M.S	F. Value	Prob.
SP	3	1.489	0.496	16.1930**	0.0000
TM	2	0.774	0.387	12.6318**	0.0002
SP x TM	6	1.291	0.213	7.0210**	0.0002
Error	24	0.736	0.031		
Total	35	4.291			

** = Highly significant at α = 0.01

Individual Comparison of Treatments Mean for Yarn Number (30^s) Carded

Spindle speed	Means*	Twist multiplier	Means*
Sp_1	29.71 b	TM_1	30.23 a
Sp_2	30.05 a	TM_2	30.03 b
Sp_3	30.18 a	TM_3	29.87 c
Sp_4	30.28 a		

(Sp x TM) Interactions for Yarn Number (30^s) Carded

Variables	Sp_1	Sp_2	Sp_3	Sp_4
TM_1	30.10 ab	31.17 ab	30.23 ab	30.40 a
TM_2	29.94 bc	29.90 b	30.15 ab	30.12 ab
TM_3	29.08 ab	30.08 ab	30.15 ab	30.16 ab

* Means bearing the same letters having non-significant differences between them at α = 0.05

Table 3: Analysis of Variance for Yarn Number 30^s Carded

S.O.V	d.f	S.S	M.S	F. Value	Prob.
SP	3	107.712	35.904	110.8495**	0.0000
TM	2	95.361	48.681	147.2091*	0.0000
SP x TM	6	5.329	0.888	2.7422**	0.357
Error	24	7.774	0.324		
Total	35	216.176			

** = Highly significant at α = 0.01

* = Significant α = 0.05

Individual Comparison of Treatments Mean for Yarn Number (30^s) Carded

Spindle speed	Means*	Twist multiplier	Means*
Sp_1	78.48 a	TM_1	74.72 b
Sp_2	76.30 b	TM_2	78.26 a
Sp_3	75.38 c	TM_3	74.90 b
Sp_4	73.69 d		

(Sp X TM) Interactions for Yarn Number (30^s) Carded

Variables	Sp_1	Sp_2	Sp_3	Sp_4
TM_1	76.69 d	74.69 ef	74.48 ef	73.03 gh
TM_2	80.87 a	79.07 b	77.68 c	75.43 e
TM_3	77.88 c	75.14 e	73.97 g	72.61 h

* Means bearing the same letters having non-significant differences between them at α = 0.05

Table 4: Analysis of Variance for Yarn Number 30^s Carded

S.O.V	d.f	S.S	M.S	F. Value	Prob.
SP	3	0.694	0.231	101.1617**	0.0000
TM	2	1.78	0.589	257.7124**	0.0000
SP x TM	6	0.850	0.142	61.9843**	0.0000
Error	24	0.055	0.002		
Total	35	2.777			

** = Highly significant at $\alpha = 0.01$

Individual Comparison of Treatments Mean for Yarn Number (30^s) Carded

Spindle speed	Means*	Twist multiplier	Means*
Sp_1	11.95 d	TM_1	11.97 c
Sp_2	12.21 b	TM_2	12.07 b
Sp_3	12.09 c	TM_3	12.39 a
Sp_4	12.32 a		

(Sp x TM) Interactions for Yarn Number (30^s) Carded

Variables	Sp_1	Sp_2	Sp_3	Sp_4
TM_1	11.80 f	11.85 f	11.86 f	12.35 b
TM_2	11.95 e	11.99 e	12.10 d	12.25 c
TM_3	12.10 d	12.80 a	12.30 bc	12.37 b

* Means bearing the same letters having non-significant differences between them at $\alpha = 0.05$

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