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Spinning Performance of Open End Yarn as Affected by Some Processing Variables

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ABSTRACT

Spinning performance of open-end yarn as affected by some variables was studied in this research work. The results indicate that the effect of yarn counts was highly significant; while the effect of draw navel type and rotor diameter was non-significant, and that of draw-off navel type was significant. However, rotor diameter exact non-significant effect on lea strength. The interaction of yarn count, Navel type, and rotor diameter (CxNxD) was highly significant. For count lea strength product, results indicated that the effect of count was highly significant while the effects of navel and rotor diameter were non-significant.

Key Words: Spinning; Yarn; Rotor diameter; Navel types

INTRODUCTION

Staple yarns have been made throughout history, first by hand, then by mechanized versions of hand spinning, then by what are now termed conventional machines i.e. ring spinning and finally by various unconventional means which definitely includes the open-end spinning system.

Open-end spinning has brought not only radical changes in the total separation of drafting, twisting and winding but also an associated increase in productivity. Previous systems have succeeded in separating no more than two of these. This step enables larger yarn packages to be made which give a saving in handling costs and permitting the use of higher speeds. The output per worker seems to fit the expectation of a logarithmic increase in productivity. Lord (1975) reported that yarn count and twist could have a surprisingly large effect on the yarn structure. He also mentioned that the requirements for large poundage of yarn could only be met by spinning coarse counts. Nield (1975) reported that the count variation for coarse counts in open-end yarn is better than yarn made from ring spinning. This study was conducted to assess the spinning performance of open end yarn as affected by some processing variables.

MATERIALS AND METHODS

The present study was carried out at Shafi Spinning Mills Sheikhupura Road, Faisalabad and in the Department of Fibre Technology, University of Agriculture, Faisalabad. The physical characteristics were estimated by high Volume Instruments (HVI)-900 SA), a fibre testing system manufactured M/s Zellweger Ltd., Switzerland. Specimen lint samples recorded span length with its mean value of 1.03 inch and CV as 0.85%, fibre uniformity ratio with its mean value 48.13% and CV as 1.35%, fibre micronaire with its mean value 4 with CV as 2.74%, fibre maturity percentage with its mean value 82.12% and with CV as 0.76%, fibre bundle strength with its mean value 84.15 x 1000 lb/in^2 with CV as 0.53%, fibre elongation percentage with its mean value 7.3% and CV as 2.88%, cotton colour with its mean value of 67.92 and CV as 0.72%, trash percentage with its mean value 1.04% and CV as 10.31% and transh count with its mean value 8.2% and CV as 5.21%. These physical characteristics were estimated by high Volume Instruments (HVI)-900 SA) a fibre testing system manufactured by M/s Zellweger Ltd., Switzerland.

Raw cotton was processed at the blow room, carding and drawing section. The drawing sliver of 0.12 hanks was fed to the open-end machine (Model SE 8, Schalafhorst, Germany). Following are the coding of the variables of the open-end machine for the current study.

1. Rotor Diameter
D1 = 33 mm; D2 = 40 mm
2. Draw-off Navel Type
N1 = Spiral grooved path with built-in four notches (KN4R4)
N2 = Built-in four coarsely grooved notches (KN4)
N3 = Built-in finely grooved spiral path. (Spiral)
3. Yarn Count
C1 = 10^s ;C2 = 16^s ;C3 = 20^s

The yarn samples thus fabricated were evaluated for the following parameters.

Yarn count. Yarn count was determined through Digital Auto Sorter-III linked with computer system IBM, which gives direct reading. A lea of 120 yards was fed to the computer to determine English Count according to its operational manual adopting procedure recommended by ASTM (1997). The yarn count was noted from its automatic digital display.

Yarn lea strength. Lea-Strength Tester was used to find the yarn lea strength in pounds. The lea of 120 yards was fed to the instrument according to the method recommended by ASTM (1997).

Count lea strength product (CLSP). Count lea strength product value was calculated by multiplying the yarn count value with the respective yarn lea strength value, according to the British Standard (1985).

CLSP = Yarn Count X Lea Strength

Analysis of data. The data were analysed statistically using three-factor factorial completely randomized design (CRD) for the interpretation of data. Duncan's new Multiple Range (DMR) was applied for individual comparison of means among the various yarn characteristics as suggested by Faqir (2000) using M Stat Micro-computer package as devised by Freed (1992).

RESULTS AND DISCUSSION

1. Yarn count. The results (Table Ia & Ib) indicate that the effect of yarn count was highly significant, while the effect of draw-off navel type and rotor diameter was non-significant. In case of interaction all the first order and second order interactions were also non-significant. DMR for the comparison of individual mean for draw-off navel type revealed that the highest value of average yarn count was 15.28^s for N3 (Spiral) followed by 15.21^s for N1 (KN4R4) and 15.2^s for N2 (KN4) draw-off navel. However, the difference in between them was non-significant. Previously, Tyagi *et al.* (1996) reported that the fine yarn show less abrasion resistance than coarse yarn and when spiral navel is used the abrasion resistance is further reduced. As regards to the yarn count the results revealed that the actual values recorded for C1 (10^s), C2 (16^s) and C3 (20^s) were 9.83^s, 15.93^s and 19.93^s, respectively and generated significant difference with each other. Nield (1975) reported that the count variation in rotor spun yarn is better than those yarns spun with ring spinning technique for coarser counts. Lord (1975) mentioned that yarn count and twist could have a surprisingly large effect on yarn structure. He also pointed out that the requirements for large poundage of fibres could only be met by spinning coarse count. Similarly, Palm (1975) concluded that open-end is designed to operate ideally at counts ranging from 10^s to 36^s.

As regards to the rotor diameter Table Ib show that the highest value of the yarn count was 15.49^s for D2 (40 mm) followed by 14.98^s for D1 (33 mm) rotor diameter. Both D1 and D2 had non-significant effect on yarn count.

Table Ia. Analysis of variance for yarn count

Source of variance	Degrees of freedom	Sum of squares	Mean square	F Value	Prob
D	1	5.812	5.812	2.5464	0.114 N.S
N	2	0.105	0.052	0.0230	1.000 N.S.
C	2	1551.708	775.854	339.9565	0.000 **
DN	2	0.078	0.039	0.0171	N.S.
DC	2	0.019	0.009	0.0041	N.S.
NC	4	0.230	0.058	0.0252	N.S.
DNC	4	0.051	0.013	0.0055	N.S.
Error	72	164.320	2.282		
Total	89	1722.322			

** = Highly Significant; * = Significant; N.S. = Non-significant

Table Ib. Comparison of individual means for yarn count

Navel Type	Count	Count	Count	Rotor Dia	Count
N1	15.21	C1	9.83 C	D1	14.98
N2	15.20	C2	15.93 B	D2	15.49
N3	15.28	C3	19.93 A		

Any two means not sharing a letter in common differ significantly at $\propto$ =0.05

2. Yarn lea strength. The statistical analysis of variance and comparison of individual mean for yarn lea strength indicate that the effect of count (C) was highly significant, while the effect of draw-off navel type (N) was only significant. However, rotor diameter (D) exert non-significant effect on lea strength. In case of interactions, the interaction of CxNxD was highly significant, while remaining interactions remained non-significant. DMR (Table IIb) for the comparison of individual means for draw-off navel type revealed that highest yarn lea strength (126.7 lb) was recorded for N1 (KN4R4) followed by 126.4 lb and 124.3 lb for N3 (Spiral) and N2 (coarsely grooved, KN4), respectively. The results show that N2 differ significantly from N1 and N3. However, N1 and N3 were non-significant with respect to each other. It could be concluded from the table 2b that four grooved navel (N2) produce a weaker yarn as compare to yarn produce by spiral draw-off navel (N1 and N3).

Steadman *et al.* (1989) have also reported that when a four grooved draw-off navel type was used the lea strength was decreased as compared to spiral navel. Likewise, Simpson and Patureau (1979) reported that the yarn spun with a coarsely grooved draw-off navel were generally weaker than those spun with a finely grooved draw-off navel type. Haranhalli (1990) mentioned that under dynamic equilibrium the peripheral twist inserted by the navel influenced the yarn strength in direct proportion.

On the other hand Tyagi *et al.* (1996) reported different results that the yarn spun with spiral navel exhibit significantly lower tenacity than their counter parts spun with notched navel. This difference may be due to different raw material used (Li & Yan, 1990) that fibre properties had a significant effect on yarn strength.

Table IIa. Analysis of variance for yarn lea strength

Source of variance	Degrees of freedom	Sum of squares	Mean square	F Value	Prob
D	1	1.111	1.111	0.0881	N.S.
N	2	100.289	50.144	3.9780	0.0230 *
C	2	193656.022	96828.011	7681.3759	0.0000 **
DN	2	58.689	29.344	2.3279	0.1048 N.S.
DC	2	30.689	15.344	1.2173	0.3021 N.S.
NC	4	115.511	28.878	2.2909	0.0678 N.S.
DNC	4	181.911	45.478	3.6078	0.0098 **
Error	72	907.600	12.606		
Total =	89	195051.822			

** = Highly Significant; * = Significant; N.S. = Non-significant

Table IIb. Comparison of individual means for yarn lea strength

Navel type	Lea strength (lb)	Count	Lea strength (lb)	Rotor dia	Lea strength (lb)
N1	126.7 A	C1	189.8 A	D1	125.9
N2	124.3 B	C2	106.3 B	D2	125.7
N3	126.4 A	C3	81.33 C		

Table IIc. Comparison of interactions means CxNxD for yarn lea strength

	C1		C2		C3	
	D1	D2	D1	D2	D1	D2
N1	193 AB	188.8 BC	103 E	107 DE	84 F	83 F
N2	188.6 BC	187 C	104.8 DE	104 DE	82.8 F	77 G
N3	187 C	193.8 A	109 D	108 DE	80 FG	80 FG

Any two means not sharing a letter in common differ significantly at $\propto$ =0.05

The yarn count highest value of lea strength was recorded as 189.83 lb for C1 (10^s) followed by 106.3 lb and 81.3 lb for C2 (16^s) and C3 (20^s), respectively. The results showed that C1 significantly differs from C2 and C3. It was the case with C2 and C3 i.e. both were significantly different from each other. It could be concluded from the Table IIb that the yarn lea strength and yarn count has an inverse relationship i.e. as the yarn count increased yarn lea strength decreased. Khalid (1987) has also reported similar results that as the yarn count becomes coarser the yarn lea strength increases for rotor yarns. He measured lea strength 175.1 lb for 10^s and 101 lb for 16^s. Likewise, Hamid (1981) found that lea strength decreases, as the yarn count becomes finer for open-end yarns. Waheed (1991) reported that the yarn strength decreases, as the yarn becomes finer.

The results in respect of lea strength of C3 (20^s) differ from those reported by Sheikh (1995) who observed the yarn lea strength of Pakistani cotton for the 20^s count as 107.8 lb. From practical point of view, fibre maturity and trash contents can influence yarn strength. Likewise Nield (1975) and Haranhalli (1990) reported that yarn made from open-end spinning is 15-20% weaker than that of ring spinning.

As regards to the rotor diameter, Table IIb indicated that yarn lea strength at D1 (33mm) and D2 (40mm) was 125.9 lb and 125.7 lb, respectively. However, these values were non-significant with respect to each other. Manoher *et al.* (1983) reported that an increase of rotor diameter upto 46mm there is hardly any effect on lea strength, while a further increase of rotor diameter upto 56mm leads significant drop in strength. Likewise, Simpson and Patureau (1979) reported that the yarn lea strength was greater with a 46 mm rotor diameter than with a 56 mm rotor diameter. Oxtoby (1987) concluded that accumulation of impurities in rotor deteriorate yarn strength. He further mentioned that small rotor diameter require more frequent cleaning. Table IIc depicted the interaction of count, navel type and rotor diameter (CxNxD). Under count C1 (10^s) maximum lea strength of 193.8 lb was recorded at the combination of spiral x 40 mm and the minimum yarn lea strength of 187 lb was recorded at the combinations of spiral x 33 mm and KN4 x 40 mm. However under C2 (16^s) maximum yarn lea strength of 109 lb was recorded was recorded at the combination of spiral x 33 mm and the minimum yarn lea strength of 103 lb was recorded at the combination of KN4R4 x 33 mm. Under C3 (20^s) maximum yarn lea strength of 84 lb was recorded at the combination of KN4R4 x 33 mm and the minimum yarn lea strength of 77 lb was recorded at the combination of KN4 x 40 mm. Spiral navel type produced the strongest yarn for 40 mm rotor diameter. While KN4R4 navel type produced the strongest yarn for 33 mm rotor diameter. Weakest yarn was produced by spiral navel for 33 mm rotor diameter. While KN4 navel produced weakest yarn for 40 mm rotor diameter. Overall best combination was C1xN3xD2 (10^s x spiral x 40 mm) and worst combination was C3xN2xD2 (20^s x KN4 x 40 mm) with their respective mean values of 193.8 lb and 77 lb.

3. Count lea strength product. The statistical analysis of variance and comparison of individual means for count lea strength product is shown in Tables IIa and IIIb, respectively. The result indicated that the effect of count (C) was highly significant, while the effect of draw-off navel (N) and rotor diameter (D) was non-significant. In case of their interactions, all the first and second order interactions remained non-significant effect. DMR (Table IIIb) indicate that highest count lea strength product (CLSP) (1742.6 hanks) was recorded for N3 (spiral) followed by 1740.1 hanks and 1704.3 hanks for N1 (KN4R4) and N2 (KN4), respectively. The results show that these values were non-significant with respect to each other. Previously, Tyagi *et al.* (1996) reported that yarn produced with spiral draw-off navel is slightly more rigid than those spun with notched draw-off navel type.

Table IIIa. Analysis of variance for count lea strength product

Source of variance	Degrees of freedom	Sum of squares	Mean square	F Value	Prob
D	1	80133.531	80133.530	2.9469	0.0903 N.S.
N	2	27638.100	13819.051	0.5082	N.S.
C	2	987865.366	493932.683	18.1643	0.0000 **
DN	2	11613.707	5806.853	0.2135	N.S.
DC	2	41281.820	20640.910	0.7591	N.S.
NC	4	33232.992	8308.248	0.3055	N.S.
DNC	4	38346.176	9586.544	0.3525	N.S.
Error	72	1957857.560	27192.466		
Total =	89				

** = Highly Significant; * = Significant; N.S. = Non-significant

Table IIIb. Comparison of individual means for count lea strength product

Navel Type	CLSP	Count	CLSP	Rotor Dia	CLSP
N1	1740.1	C1	1871 A	D1	1699.2
N2	1704.0	C2	1695 B	D2	1758.8
N3	1742.6	C3	1621 B		

Any two means not sharing a letter in common differ significantly at $\propto$ =0.05

As regards to the yarn count, the results indicate that the highest value of count lea strength product was 1871 hanks for C1 (10^s) followed by 1695 hanks and 1621 hanks for C2 (16^s) and C3 (20^s), respectively. The results show that C1 significantly differs from C2 and C3. However, C2 and C3 were non- significant with respect to each other. It was evident that the fine yarns possess less count lea strength product value than coarse count yarns. Similar results were reported by Khalid (1987) who revealed that finer count spun on rotor machine has less value of count lea strength product as compared to coarser count yarn. He found that the CSP value 1785.95 hanks for 10^s and 1613 hanks for 16^s of cotton variety MNH-93. Likewise, Hamid (1981) concluded same results on rotor machine. Waheed (1991) reported that the yarn lea strength decreases as the yarn becomes finer. Hence, the count lea strength product of fine count is lesser as compared to coarse counts.

As regards to the rotor diameter Table IIb indicates that count lea strength product at D2 (40 mm) and D1 (33 mm) was 1758.8 hanks and 1699.2 hanks, respectively. The result indicated that the values were non-significant with respect to each other. Previously, Barella *et al.* (1983) reported that yarn tenacity and elongation percentage were affected by rotor speed in linear manner but the rotor diameter affect these parameters both linearly and quadratically. Manohar *et al.* (1983) reported that an increase of rotor diameter up to 46 mm has hardly any effect on yarn lea strength, while a further increase of rotor diameter up to 56 mm leads significant drop in lea strength. So count lea strength product also remained unaffected by rotor diameter. As count lea strength product is the product of count and lea strength and yarn lea strength does not depend upon rotor diameter up to 46 mm, this means result were in line with the above researchers. Oxtoby (1987) reported that the accumulation of impurities deteriorate yarn strength. He further mentioned that rotor diameter was closely related to fibre length.

REFERENCES

ASTM Committee, 1997. Standard test method for measurement of cotton fibre by High Volume Instruments (HVI) Spin lab System of Zellweger, Uster, Inc. ASTM Designation D 4605-86. *ASTM Standards on Textile Materials Amer. Soc. For Testing and Materials,* Philadelphia, U. S. A.

Barella, A., A.M. Manich, N. Patricia, Marino and J. Garofalo, 1983. Factorial studies in rotor spinning part 1: cotton yarns. *J. Text. Inst.,* 6: 329–39.

British Standards, 1985. Determination of lea strength and lea count of spun yarn methods of test for textiles. *B.S. Handbook II. British Standards Inst., London,* pp: 141–2.

Faqir, M., 2000. *Statistical Methods and Data Analysis.* Kitab Markaz, Bhawana Bazar, Faisalabad–Pakistan

Fareed, R.D., 1992. *M. Stat Microcomputer Statistical Programme.* Michigan State, University of Agriculture, Norwey. 3248. Agriculture Hall, East Lausing, Michigan Lausing, U.S.A.

Hamid, A., 1981. Studies for optimum twist multiplier on open-end for cotton. *M.Sc. Thesis,* Deptt. of Fibre Tech., University of Agriculture, Faisalabad.

Haranhalli, A.S., 1990. *Practical open-end Spinning,* pp: 14-41. Mahajan Book Distributors. Ahmedabad, India.

Khalid, A.S., 1987. Studies for optimum rotor speed on open-end for Pakistan cotton. *M.Sc. Thesis,* Deptt. of Fibrte Technology, University of Agriculture, Faisalabad.

Li, Y. and H. Yan, 1990.Measuring unevenness and bland ratio of yarns with micronaire resonators. *Text. Res. J.,* 60: 54–5

Lord, P.R., 1975. The fabric of open-end and ring spinning. *Proc. Tech. Seminar, National Cotton Council, Taxas,* pp: 19–21.

Manohar, J. S., A.K. Rakshit and N. Balasubramanian, 1983. Influence of rotor speed, rotor diameter, and carding conditions on yarn quality in open-end spinning. *Text. Res. J.,* 53: 497–503.

Nield, R., 1975. *Open-end spinning. (Textile Institute monograph No. 1),* pp: 17–9. The Textile Institute, Manchester, U.K.

Oxtoby, E., 1987. *Spun Yarn Technology,* pp: 138–57. Butterworths and Co. Ltd.,U.K.

Palm, C.W., 1975. Principles and characteristics of open-end machinery. *Proc. Tech. Seminar. National Cotton Council. Taxas,* pp: 10–11.

Sheikh, H.R., 1995. Some observations on moisture relations with imperfections content of cotton yarn. *Pakistan Tex. J.,* 44: 31–3.

Simpson, J. and M.A. Patureau, 1979. Effect of rotor speed on open- end spinning and yarn properties. *J. Text. Inst.,* 79: 468–573.

Steadman, R.G, J.R. Gipson, R.D. Mehta and A.S. Soliman, 1989. Factors affecting rotor spinning of fine cotton yarns. *Text. Res. Inst.,* 371–82.

Tyagi, G.K., A.K. Choudhary and R.K. Varshney, 1996. Contribution of draw-off nozzle profile to certain characteristics of acrylic cotton rotor spun yarns. *Indian J. Fib. & Text. Res.,* 21: 261–4.

Waheed, A., 1991. Comparative study on some physical properties and spinning performance of new cotton variety RH-1 with existing commercial varieties FH-87, MNH-93, MNH-129 and NIAB-78. An *M.Sc. Thesis,* Deptt. of Fibre Tech., University of Agriculture., Faisalabad.

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