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A Novel Yarn Cross-Sectional Area Calculation Method: Effect of Yarn Cross-Sectional Area on Yarn Quality Parameters

Prof. Ramesh N. Narkhedkar
D.K.T.E'S Textile and Engineering Institute, Ichalkaranji.

Abstract

In the recent days every textile technologist requires the production of yarn with higher quality and with high yarn realization percentage. It can be made possible if the textile technologist takes the improvement steps on the machine parameters as well as processing parameters. Up till now much more modern developments have been done in the machines for improving the yarn quality now everybody is looking for encouraging the yarn quality by improving processing parameters. In this study the important processing parameter i. e. twist multiplier which is having dominant effect on yarn cross-sectional area, has been considered for testing its effect on the yarn quality, and an attempt has been made to put correlation of yarn cross-sectional area with yarn quality parameters.

Introduction

In this study the yarn cross-sectional area has been accurately measured by the instrument developed by R. N. Narkhedkar et al [7]. In this study the author has been developed a novel method for measuring an accurate yarn cross-sectional area without cutting the yarn, and attempted to correlate the same with yarn quality parameters such as: tenacity, unevenness, imperfections and hairiness.

Material and Method

In this study the author processed the combed & carded material for producing three different counts viz. 20s Ne, 30s Ne & 40s Ne with three different twist multipliers such as: 3.6, 4.2 & 4.8 for each count, which affects the yarn cross-sectional area. Then those yarns are tested for their quality parameters for making an attempt to coordinate yarn cross-sectional area with yarn quality parameters. Following table 1 shows the material specifications and processing parameters.

Table 1. Material specification and process parameters

Parameters	20s Ne	30s Ne	40s Ne
Bobbin hank (carded and combed)	0.85	0.85	0.85
Actual draft	22.22	33.33	44.44
Required draft	22.88	34.32	45.77
Break draft	1.2	1.2	1.2
TM	TPI	TPI	TPI
3.6	16.09	19.71	22.76
4.2	18.78	23	26.56
4.8	21.46	26.29	30.57
Spacer	4.0mm	3.5mm	3.5mm
Traveler	2/o UM1 UDR	5/o UM1 UDR	7/oUM1 UDR

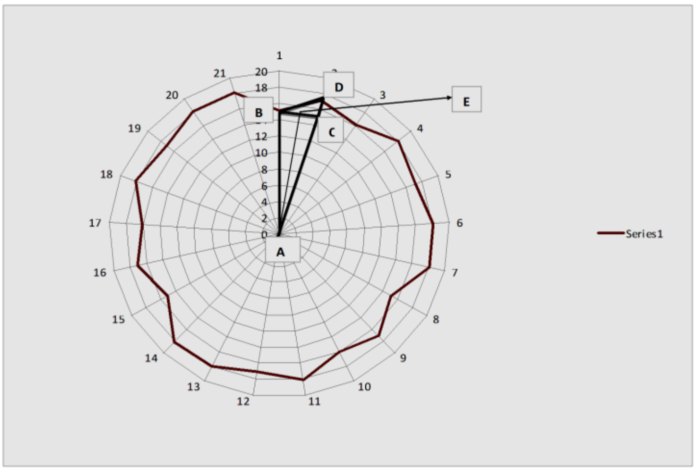

Figure 1 Yarn cross-section

Conventionally the yarn cross-sectional area was calculated by considering the yarn as a circular but it is an assumption. Following method gives the yarn cross-sectional area accurately.
Figure 1 shows a yarn cross-section taken for area measurement.
Let,
Min radius of yarn cross-section L (AB) = L (AC) = R (min)
Now the measurement of yarn radius has been taken for each 3.6° yarn rotation,
∵ < (CAE) = < (BAE) = 1.8°
And L (CE) = L (EB) = Sin (1.8) X L (AC) = 0.031411 X R (min)
∵ L (BC) = 2 x L (CE) = 0.06282152 X R (min) ------------------------------ (1)
Now,
< (BAC) = 3.6 which is very small for the yarn cross-section area.
∴ Δ (BCD) can be assumed as a right angle triangle.
∵ A (ΔBCD) = ½ x Base x Height
= ½ x L (BC) x L (CD)
= 0.031411 x R (min) x [L (AD) – L (AC)]
= 0.031411 x R (min) x [L (AD) – R (min)]
Where, L (AD) = R1, R2, R3.................. R100
∵ Remaining area of yarn cross-section outer the circle with R (min) is
= ∑ [All triangles outside the circle with R (min)] ------------------------- (2)
Now, Area of circle with R (min) is = π x [R (min)] ² ------------------------------- (3)
∵ Total Yarn Cross-sectional Area = (2) + (3)

Results and Discussion

The following table 2 shows the variation in yarn cross-sectional areas with respect to the different Twist Multipliers for three different counts.

Yarn Count	Twist Multiplier	Yarn Cross-Sectional Area
20s Ne	3.6	0.03799
	4.2	0.02894
	4.8	0.024894
30s Ne	3.6	0.02959
	4.2	0.023513
	4.8	0.018454
40s Ne	3.6	0.019242
	4.2	0.01514
	4.8	0.010078

For testing the effect of Twist Multiplier on the yarn cross-section area, the fabricated testing instrument is used. The yarn quality parameters of above mentioned yarn are as given in table 3 and the effect of change in yarn cross-sectional area on yarn quality parameters is as shown in table 4.

Table 3. Yarn quality parameters

Count	Tm	For Carded Yarn				For Combed Yarn			
		Total IPI	U%	Hairiness (H3)	Tenacity	Total IPI	U%	Hairiness (H3)	Tenacity
20s Ne	3.6	1036	13.13	747	17.96	82	9.12	618	19.97
	4.2	1082	13.22	783	20.77	83	9.16	638	23.20
	4.8	1000	13.21	852	20.54	100	9.39	708	22.69
30s Ne	3.6	2650	15.73	365	16.07	320	10.98	334	18.97
	4.2	2847	15.84	434	17.56	287	10.95	392	20.69
	4.8	3050	16.11	445	20.33	267	11.02	488	19.94
40s Ne	3.6	4721	17.73	365	14.49	548	12.13	333	17.52
	4.2	4640	17.6	424	17.32	545	12	350	18.60
	4.8	4835	17.53	461	16.91	524	12.13	360	19.59

Table 4 % Reduction in yarn C/s & % Change in Parameters

Count	For increase in Twist Multiplier	% Reduction in yarn C/s	% Change in Parameters							
			For Carded Yarn				For Combed Yarn			
			IPI	U%	Hairiness	Tenacity	IPI	U%	Hairiness	Tenacity
20s Ne	3.6 to 4.2	23.82%	4.44	0.680	4.8200	15.65	1.22	0.437	3.2400	16.17
	4.2 to 4.8	13.98%	1.64	-0.076	8.8100	-1.120	20.5	2.449	10.970	-2.198
30s Ne	3.6 to 4.2	20.54%	7.43	0.694	18.900	9.270	-6.97	0.273	17.370	9.070
	4.2 to 4.8	21.52%	7.13	1.676	2.5300	15.77	-10.3	0.363	24.500	-3.620
40s Ne	3.6 to 4.2	21.32%	0.40	-0.739	16.160	19.53	-3.85	-1.08	5.1100	6.164
	4.2 to 4.8	33.44%	2.00	-0.399	8.7300	-2.430	-0.55	1.071	2.8600	5.320

- Sign indicates % reduction.

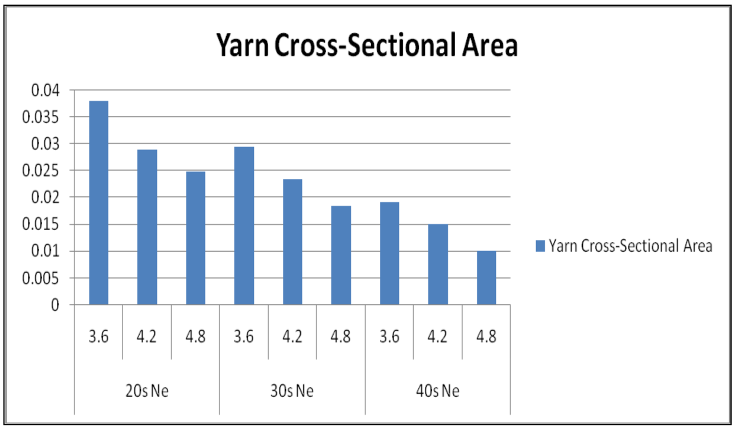

Figure 2

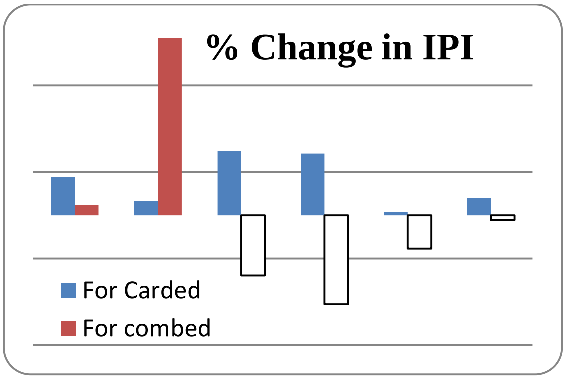

Figure 3

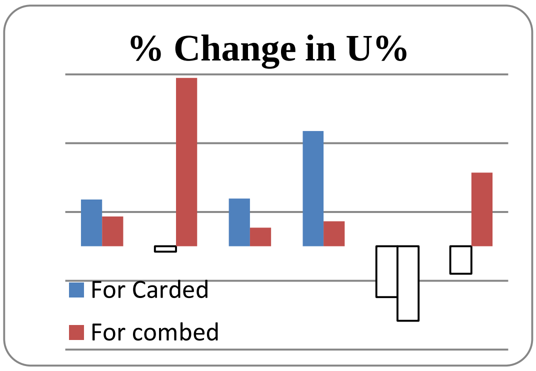

Figure 4

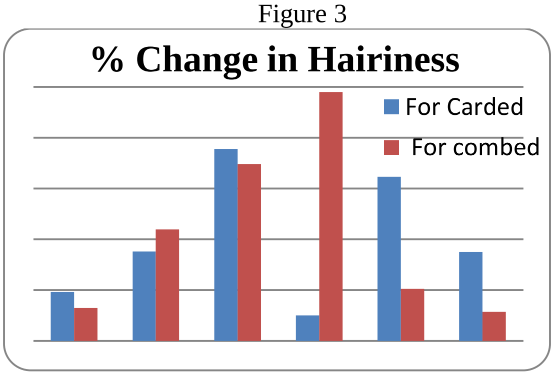

Figure 5

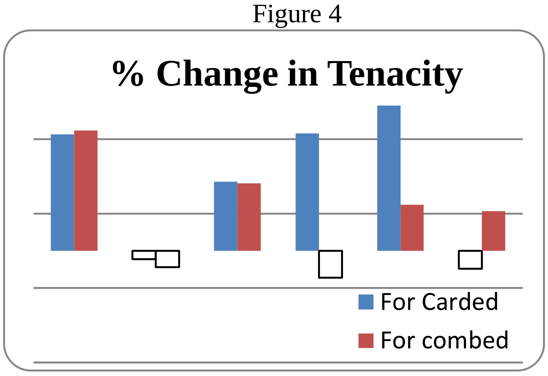

Figure 6

Above table 2 & figure 2 revels that, if the count becomes finer or yarn T.M. increases for a particular count, the yarn cross-sectional area reduces by 15 to 30% due to the increase in yarn packing density.
It is also confirmed that, as T.M. increases for carded material yarn IPI increases for all counts by the increase in thick-thin places due to higher short fibre content. While in combed yarn for 20s Ne IPI increases with the reduction in yarn cross-section, due to more bulk material twisted with higher T.M. giving more expose to the IPI, and for finer counts it reduces due to less number of fibres compacted with higher T.M. For carded and combed material the yarn U% increases as T.M. increases, due to the increase in yarn thick and thin places, but for finer counts it found to be reduced due to better contribution of longer fibers. For both the materials yarn hairiness increases due to increase in percentage of protruding fibres. It is also found that, as the twist multiplier increase from 3.6 to 4.2 the yarn tenacity & elongation at break, increases even if the yarn cross-sectional area reduces by 24% due to the increase in yarn compactness. But from 4.2 to 4.8 yarns tenacity & elongation at break, are found to be reducing due to the twist obliquity effect and increase in yarn rigidity, but in case of finer yarn tenacity is found to be increased as T.M. increases up to 4.8 since it is a requirement due to less number of fibres in yarn cross-section. .

Conclusions

Conventional method of calculating the yarn cross-sectional area gives the area of circle corresponding to the radius taken but the novel method developed by us gives the correct yarn cross-sectional area irrespective of the any one radius.
Correct, fast and easily yarn cross-sectional area can be calculated due to the software interference by this method. As the twist multiplier increases the reduction in yarn cross-sectional area for coarser counts is only 13% to 20% due to higher number fibres in cross-section, while the reduction is increased to 20% to 35% in case of fine counts due to higher compactness offered by the less number of fibres in yarn cross-section. In case of carded material the yarn IPI is increased with reduction in yarn cross-sectional area, while for combed material there is increase in IPI only for coarse counts and it reduces for finer counts as the yarn cross-sectional area reduces. For carded and combed material in the coarse counts the yarn U% increases as T.M. increases, but for finer counts it found to be reduced as well as yarn hairiness is found to be increases with respect to reduction in yarn cross-sectional area. It is found that yarn twist multiplier should be used optimum according to the count to be spun which gives higher yarn tenacity, too low or too high T.M. affects the yarn cross-sectional area resulting in to reduction in yarn tenacity.

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