Indian Journal of Textile Research
Vol. 6, September 1981, pp. 97-100

Effect of Rotor Speed and Combing Roller Speed on Yarn Characteristics and Minimum Spinning Twist

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Received 9 *January* 1981; *accepted* 14 *May* 1981

The spinning performance and yarn quality of an Indian cotton (J-34) was studied by spinning it to 10^s, 16^s and 22^s yarn over a range of rotor speed (30,000-50,000 rpm) and combing roller speed (4000-9000 rpm). The strength of yarn decreased and yarn unevenness and imperfections increased as the rotor speed was increased. The minimum spinning twist was, however, lower at higher rotor speeds. Too low a speed of combing roller (e.g. 4000 rpm) resulted in poor yarn quality and higher minimum spinning twist. There was practically no improvement in yarn quality and the minimum spinning twist at combing roller speeds higher than 7000 rpm.

Ever since the first commercial rotor spinner BD200 appeared in the world market, every major textile machinery manufacturer has tried to improve the basic design so as to achieve better yarn quality and higher production rates. In general, the limit to rotor speed is not a technological but an economical one. This economic limit restricts the rotor to speeds which vary from country to country and situation to situation depending upon the power cost which goes up very steeply with increase in speed. This limit is generally agreed to be around 50,000 rpm.

Another factor which has received equal, if not more, attention is the effect of such increase in rotor speed on the spinning performance and the yarn characteristics. Grosberg and Mansour[1] studied the effect of speed varying from 20,000 to 100,000 rpm on yarn characteristics and found that the yarn tenacity generally increased but elongation at break decreased, and that weight per-unit-length variability increased. Similar results have been reported from a study on a Schubert and Salzer RK-10 rotor spinner where the rotor speed was increased from 20,000 to 45,000 rpm[2]. On the other hand, workers have reported contrary results, viz. deterioration in yarn quality with increase in rotor speed. Artzt[3,4] found that the yarn strength, elongation and uniformity deteriorated as the rotor speed was increased from 40,000 to 60,000 rpm. Grau[5] also found that the strength of the cotton yarn decreased as the speed was increased from 40,000 to 50,000 rpm. Another study[6], made on Toyoda open-end machine, revealed that the rotor speed had little effect on the strength of cotton and polyester-blended yarns. Shaw[7] also reported somewhat similar findings with cotton and viscose rayon. Recently, entirely different conclusions were arrived at by Simpson and Patureau[8], who found that for coarse yarns (49 mg/m), the strength increased with increase in rotor speed up to 40,000 rpm, beyond which the strength started decreasing. For a slightly finer yarn (25 mg/m), a consistent drop in strength was observed as the rotor speed was increased from 25,000 to 60,000 rpm.

The above studies show how the differences in the materials and the machines have resulted in entirely different results. This means that one has to actually take trials with the material and the machine for evaluating the effect of speed on yarn quality. The present paper gives results of a study on the influence of rotor speed on the characteristics of yarns spun from a short staple Indian cotton (J-34) with a view to finding out the optimum rotor speed. Studies have also been made on the minimum spinning twist to indirectly assess the spinning performance under a given combination of machine parameters.

Materials and Methods

Indian Cotton J-34 (60% roller ginned and 40% saw ginned) of 24 mm staple having a fineness of 4.0 μg/in was used for all the spinnings.

The cotton was processed in a conventional blowroom and carded on a semi-high production card. The card sliver was given three passages of drawing on Platts drawframe having a conventional 4/4 drafting system. The finisher sliver hank was 0.136.

The finisher sliver was spun to three counts, viz. 10^s, 16^s and 22^s, on Suessen open-end spintester at rotor speeds of 30,000, 40,000 and 50,000 rpm. For each rotor speed, the combing roller speed was varied from 4000 to 9000 rpm. The twist-multiplier used for all the spinnings was kept at 5.

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The Uster single thread tester was used for testing the strength and breaking elongation of the yarn. The yarn evenness was measured on the Uster evenness tester.

In each spinning, the minimum spinning twist was also determined by increasing the yarn take-off and sliver feed rate simultaneously (to keep the yarn count constant) until the yarn broke.

Results and Discussion

Yarn characteristics—The effect of rotor speed on yarn characteristics for 10^s, 16^s and 22^s yarn at various combing roller speeds is shown in Tables 1-3. For all the three counts, in general, the yarn strength decreases as the rotor speed is increased from 30,000 to 50,000 rpm. On the other hand, increase in combing roller speed results in a sharp fall in the yarn tenacity. This is in agreement with the findings of some other researchers[9,10] and is mainly attributed to the greater extent of fibre length shortening due to fibre breakage. Apart from the reduction in fibre length, mechanical stresses imposed on the fibre may be reducing its strength and elongation, as reported by London and Jordon[11].

Several hypotheses have been put forward to explain why yarn strength decreases as the rotor speed is increased. According to one hypothesis, the yarn roughs up at the surface of the doffing navel because of the high yarn tension at high speeds[4]. Another study has shown that this is due to an increase in the wrapper fibres because of the lengthening of tying-in zone[12]. Simpson and Patureau[8] have attributed it to the increase in the twisting torque with increase in the rotor speed, tending to disturb the fibre orientation and the very short-term uniformity.

The yarn breaking elongation, on the other hand, goes down as the rotor speed increases. Such reduction in the yarn breaking elongation has also been reported by Stalder[13]. He attributed this reduction to the increase in yarn tension, which is proportional to the square of the rotor speed. The results obtained in this study also show that the yarn breaking elongation decreases with increase in the combing roller speed. Tooka[14] has also reported that as the combing roller speed increases, the extent of fibre shortening increases and fibre elongation reduces, resulting in a lower value of breaking elongation for rotor-spun yarn.

The results on yarn uniformity show that the yarn unevenness (U%) tends to go up as the rotor speed is increased. Similar results have been reported by other research workers[8,13,15]. The increase in unevenness could be due to the fact that at high production speeds, fibre individualization is poor because of the higher feed rate of sliver. This increases the average number of fibres per fibre aggregate, leading to high short-term irregularity. That fibre individualization can play an important role in the uniformity of yarn is further confirmed by the general downward trend in U% as the combing roller speed is increased. Beyond the combing roller speed of 7000 rpm, the U% values show very

Table 1—Effect of Rotor Speed and Combing Roller Speed on Yarn Characteristics (10^s Yarn)

Rotor speed rpm	Combing roller speed rpm	Tenacity g/tex	Breaking elongation %	U%	Yarn imperfections/1000 m		
					Thin	Thick	Neps
	4000	9.3	8.1	10.2	2	21	44
	5000	9.2	7.6	9.6	0	2	18
30,000	6000	8.9	7.0	8.9	0	2	16
	7000	8.2	7.4	8.8	2	2	10
	8000	7.6	7.0	9.2	2	4	34
	9000	7.7	8.3	8.4	2	4	20
	4000	9.3	7.8	11.6	10	44	114
	5000	9.2	7.3	10.9	3	6	55
40,000	6000	8.3	7.3	9.5	0	2	28
	7000	7.6	7.2	9.8	0	2	17
	8000	7.6	7.1	9.7	0	4	22
	9000	7.4	7.0	10.1	4	4	51
	4000	9.5	6.6	12.9	22	92	218
	5000	9.3	7.0	11.4	6	22	166
50,000	6000	8.5	6.7	10.7	4	14	118
	7000	7.8	6.0	10.7	4	12	110
	8000	7.7	6.2	10.8	4	14	73
	9000	7.3	5.6	10.6	12	14	114

little change, possibly due to the fact that at such a high speed fibre individualization is already adequate and further increase in speed does not improve individualization. The thick places, thin places and neps also show an upward trend with increase in rotor speed for all the three counts. The imperfections, in general, decrease with increase in combing roller speed, except at 9000 rpm, when there is a slight increase in the number of imperfections in some cases. These observations can be explained in a more or less similar way as for yarn unevenness.

The yarn quality seems to be slightly better when the cotton is spun to a coarser count. However, these differences in yarn quality parameters seem to be insignificant in comparison to much larger differences expected for ring-spun yarns.

Minimum spinning twist—From the results for minimum spinning twist (Table 4), it is seen that with increase in rotor speed the minimum twist factor decreases. This could be due to the high twisting torque operating at higher speeds and a compact packing of fibres in the rotor groove. At a low rotor speed, the

Table 2—Effect of Rotor Speed and Combing Roller Speed on Yarn Characteristics (16^s Yarn)

Rotor speed rpm	Combing roller speed rpm	Tenacity g/tex	Breaking elongation %	U%	Yarn imperfections/1000 m		
					Thin	Thick	Neps
	4000	8.8	6.2	11.1	3	26	151
	5000	8.5	6.4	10.6	5	7	102
30,000	6000	7.9	5.9	10.3	4	10	81
	7000	7.6	6.0	9.9	1	10	62
	8000	7.4	5.6	9.5	0	10	56
	9000	6.7	5.3	9.7	0	6	56
	4000	8.2	6.5	12.2	25	70	226
	5000	7.3	5.4	10.4	2	22	97
40,000	6000	6.9	5.6	10.3	2	9	34
	7000	6.3	5.4	10.5	2	5	46
	8000	6.5	5.5	9.9	0	0	43
	9000	6.4	5.6	10.1	2	8	44
	4000	7.4	6.2	12.3	20	84	330
	5000	7.0	5.5	11.6	16	20	194
50,000	6000	6.9	5.2	11.0	8	20	232
	7000	6.7	5.6	10.6	8	13	179
	8000	6.7	5.4	10.7	8	12	166
	9000	6.6	5.1	10.9	13	12	116

Table 3—Effect of Rotor Speed and Combing Roller Speed on Yarn Characteristics (22^s Yarn)

Rotor speed rpm	Combing roller speed rpm	Tenacity g/tex	Breaking elongation %	U%	Yarn imperfections/1000 m		
					Thin	Thick	Neps
	4000	8.5	7.9	11.4	2	26	165
	5000	8.8	7.3	10.5	0	16	120
30,000	6000	7.9	6.7	10.3	0	17	98
	7000	7.8	6.8	10.1	3	12	74
	8000	7.1	6.6	10.1	4	10	96
	9000	7.0	6.6	9.9	2	2	26
	4000	8.7	6.7	11.3	1	28	254
	5000	8.6	6.4	10.9	3	20	252
40,000	6000	7.8	5.7	10.6	0	14	150
	7000	7.0	5.2	10.9	16	31	158
	8000	6.4	4.9	10.5	8	10	86
	9000	5.8	4.4	10.4	8	9	88
	4000	7.3	6.5	12.1	4	45	364
	5000	6.9	6.0	11.8	20	30	262
50,000	6000	6.8	6.3	11.3	16	26	234
	7000	6.9	6.7	10.6	8	12	211
	8000	6.0	5.4	10.8	10	13	162
	9000	5.8	5.4	10.5	8	10	146

Table 4 Effect of Rotor Speed and Combing Roller Speed on Minimum Spinning Twist

Count Ne	Rotor speed rpm	Combing roller speed, rpm					
		4000	5000	6000	7000	8000	9000
	30,000	32.9*	31.9	31.6	31.2	31.2	31.2
10^s	40,000	31.0	30.7	30 3	30.3	30.3	30.3
	50,000	29.7	28.7	28.5	28.5	28.5	28.5
	30,000	25.3	24.8	24.3	23.9	23.9	23.5
16^s	40,000	23.0	22.5	22.5	22.3	22.3	22.1
	50,000	20.9	20.4	20.2	20.2	20.2	20.2
	30,000	25.9	25.3	25.1	25.1	25.1	25.1
22^s	40,000	25.2	24.5	24.1	24.1	24.1	24.1
	50,000	24.9	24.0	23.8	23.7	23.6	23.4

*Minimum twist factor ($tex^{1/2}$ turns/cm).

fibre ring is broad and the fibres are loosely packed. Though the fibres are easy to twist initially, they absorb the torque energy over a short length. In contrast, at a higher rotor speed, once the initial twisting resistance of the fibre band has been overcome, the more compact structure enables the twist to propagate more readily in a longer tying-in zone; this results in good spinning stability.

The minimum spinning twist also shows a downward trend with increase in combing roller speed. This could be partly due to the better fibre individualization achieved at higher speeds, as is reflected in the lower values of yarn unevenness and imperfections.

The minimum spinning twist first shows a drop as the yarn count is increased from 10^s to 16^s and then a rise when the yarn count is further increased to 22^s.

Conclusion

The yarn tenacity decreased as the rotor speed was increased from 30,000 to 50,000 rpm for all the three counts, viz. 10^s, 16^s and 22^s, spun from Indian cotton J-34. However, it must be kept in mind that the effect of rotor speed on yarn tenacity could be different, depending on the make and type of the rotor spinner. The yarn unevenness and imperfections were higher when the rotor speed was increased. The minimum spinning twist was observed to be lower at higher rotor speeds. Therefore, before deciding on the rotor speed, one must take into account its counteracting requirements from the point of view of yarn quality and the spinning performance.

Regarding the optimum combing roller speed, it appears that, in general, too low a speed like 4000 rpm tends to deteriorate the yarn quality. On the other hand, there is practically no gain in terms of yarn quality beyond a speed of 7000 rpm.

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