Influence of Spindle Speed on Yarn Quality of Flax/Cotton Blend

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Abstract: The influence of spindle speed on yarn quality was investigated. The yarn properties such as strength, breaking extension, imperfections and hairiness were studied. The strength of 39 tex 10/90 flax/cotton blended yarn was seen to have a lower value than the 59 tex equivalent yarn as spindle speed increased. But the breaking extension decreased with the increase in spindle speed. The study also revealed that both yarn hairiness and total imperfections increased as the spindle speed increased. It was judged from the experimental findings that the yarn produced from 10/90 flax/cotton blend had higher strength and was more regular than the yarn produced from 70/30 flax/cotton blend.

Keywords: Spinning speed, yarn quality, flax, cotton, strength, extension and imperfections.

INTRODUCTION

In staple yarn manufacture, ring spinning system is still over-shadowing the spun yarn production techniques amongst all the spinning systems, mainly because of the special characteristics of these yarns which provide excellent apparel fabric properties [1,2]. Different unconventional spinning techniques such as rotor, friction and air jet systems produce yarns at a much faster rate than the ring spinning system. But these yarns are not comparable with ring yarns in terms of strenght, especially as an end product of fabric for apparels [3,4].

The productivity of ring frame is a major factor contributing to the profitability of a spinning mill and higher spindle speed has become necessary for higher productivity [5]. Problems encountered in spinning yarns at high spindle speeds include yarn breakage rate, hairiness, strength loss and fly generation [1,6]. Consequently, production of acceptable yarn is achieved only at relatively low speeds.

The present study aims to investigate the effects of three different ring spinning spindle speeds on the quality of flax/cotton blended yarns produced, and thereby to ascertain the optimum spindle speed level for better yarn quality.

MATERIALS AND METHODOLOGY

Materials

The raw materials include dew-retted flax straws and cotton. The retted flax straws were obtained from North West Province of South Africa, and cotton fibres were obtained from KwaZulu-Natal Province of South Africa. The extracted flax fibres were processed on Temafa machines (Lin-Opener and Lin-Star) before blending with cotton in the blendomat.

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Methodology

Before blending the flax and cotton fibres, the mean fibre length of the two fibres were measured by using a Bear sorter method. The resulting length distribution diagram was used for calculating the mean fibre length, upper quartile length or effective length and short fibre percentage.

The blending of the two fibres (flax and cotton) was done on blendomat in proportions of 10/90, 30/70, 50/50 and 70/30 flax/cotton. This was followed by drawing and drafting of the sliver to the required mass per unit length to obtain the roving needed for ring spinning.

A roving of 0.6Ktex was used to produce 39 tex and 59 tex yarns for each of the 10/90, 30/70, 50/50 and 70/30 flax/cotton blends. Spinning was carried out on a double sided Zinser 319 ring frame with 152 spindles on both sides. Variable spindle speeds of 7000, 9000 and 11000rpm respectively were used for the production of all the yarn samples. Although, it was difficult to spin fine count (39 tex) from 70/30 flax/cotton blend under high spindle speeds due to unsuitable spinning conditions.

Conditioning of the Samples

All the yarn samples were conditioned for 24 hours under standard atmospheric conditions of 21±1ºC and a relative humidity of 65±2%.

Testing of the Samples

Single yarn strength (tenacity), hairiness, irregularity (U%) and imperfections of all the samples were carried out at standard conditions [7].

The Titan Universal Strength Tester at a gauge length of 500 mm with a maximum load of 6000 cN/tex was used for single yarn strength measurement. The hairiness index H, which is the measurement unit for hairiness of approximately 1 cm length of yarn was obtained from the Zellweger Hairiness meter. The Zellweger Hairiness is a component attached to the Uster Evenness Tester, which scans the total

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length of all the fibres protruding from the yarn surface measured on the 1cm yarn length.

Yarn unevenness and imperfections were observed on the Uster Evenness Tester UT3 at a testing speed of 400 m/min for 1 minute, keeping thin level at -50%, thick level at +50% and neps level at +200% for a time period of 1 minute.

RESULTS

Table 1. Properties of Flax and Cotton Fibres

Property	Flax	Cotton
Linear density (mtex)	373	165
Colour	Grey	Whitish- Yellow
Short fibre content (%)	6.56	4.1
Mean fibre length (mm) (upper quartile)	57	22
Tenacity (cN/tex)	27	16.9
Micronaire	5.2	4.2
Extension (%)	10.5	11.9

Table 2. Influence of Spindle Speed on Tenacity and Extension of Flax/Cotton Blended Ring Spun Yarns

Blend Ratio (F/C)	Linear Density (tex)	Spindle Speed (rpm)	Tenacity (cN/tex)	CVm (%) of Tenacity	Extension (%)	CVm (%) of Extension
10/90	39	7000	17.90	7.13	7.64	5.84
		9000	18.14	8.80	6.84	8.17
		11000	18.46	8.37	6.66	6.32
	59	7000	18.60	5.82	7.80	6.05
		9000	19.36	7.76	7.51	4.50
		11000	19.87	5.07	7.05	8.21
30/70	39	7000	10.73	22.21	5.81	13.39
		9000	11.91	15.67	5.54	9.28
		11000	12.47	15.82	5.43	13.06
	59	7000	11.49	10.65	6.11	12.28
		9000	12.98	12.20	6.02	9.10
		11000	13.45	17.76	5.93	15.39
50/50	39	7000	10.21	15.22	4.51	11.67
		9000	10.48	11.58	3.92	9.81
		11000	10.68	17.06	3.36	13.67
	59	7000	10.29	16.17	5.85	12.99
		9000	11.88	16.78	5.37	12.54
		11000	11.96	17.83	5.62	14.46
70/30	39	7000	4.87	23.17	2.34	31.72
		9000	4.89	24.54	2.10	17.35
		11000(N/P)	N/P	N/P	N/P	N/P
	59	7000	6.53	25.28	4.91	22.17
		9000	6.73	20.72	3.16	18.69
		11000	6.28	21.04	3.21	19.18

N/P = Not Possible to Spin, F – Flax, C - Cotton.

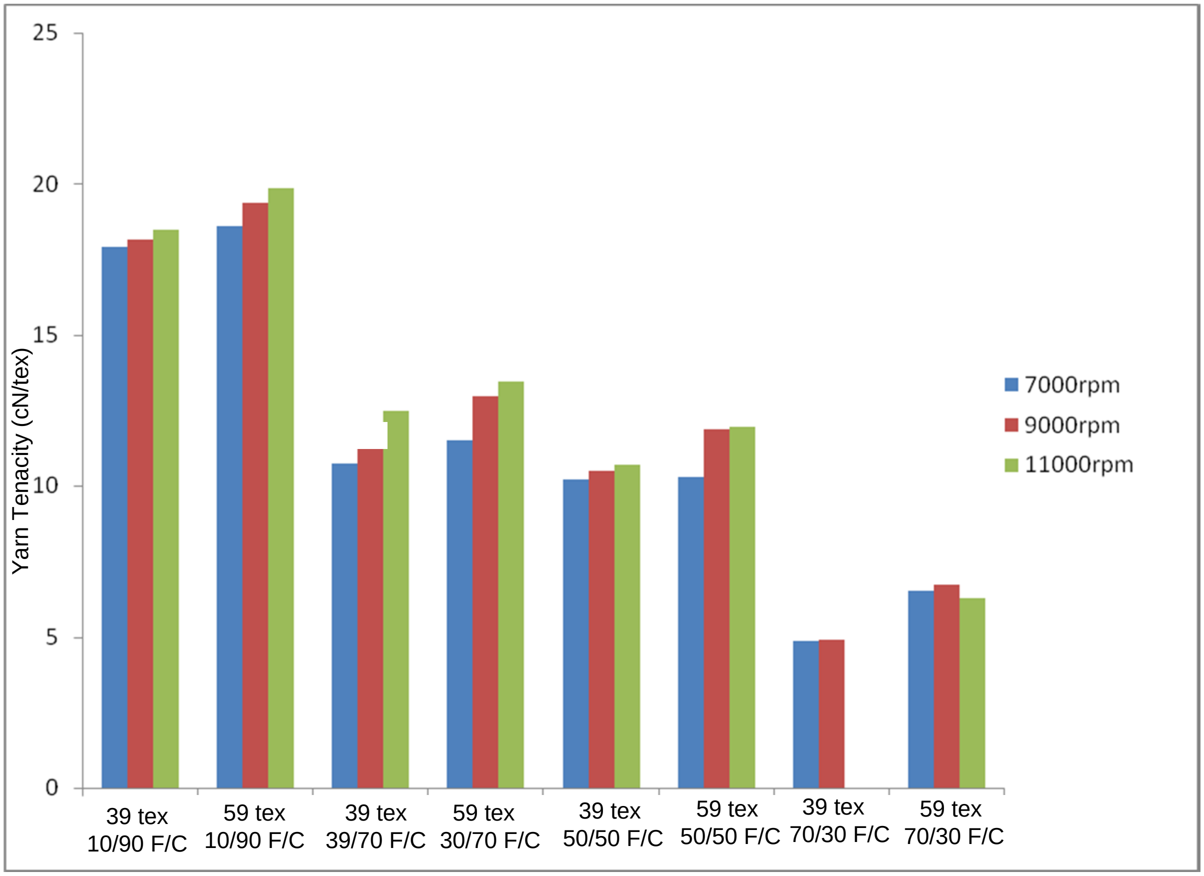

Fig. (1). Influence of spindle speed on yarn tenacity.

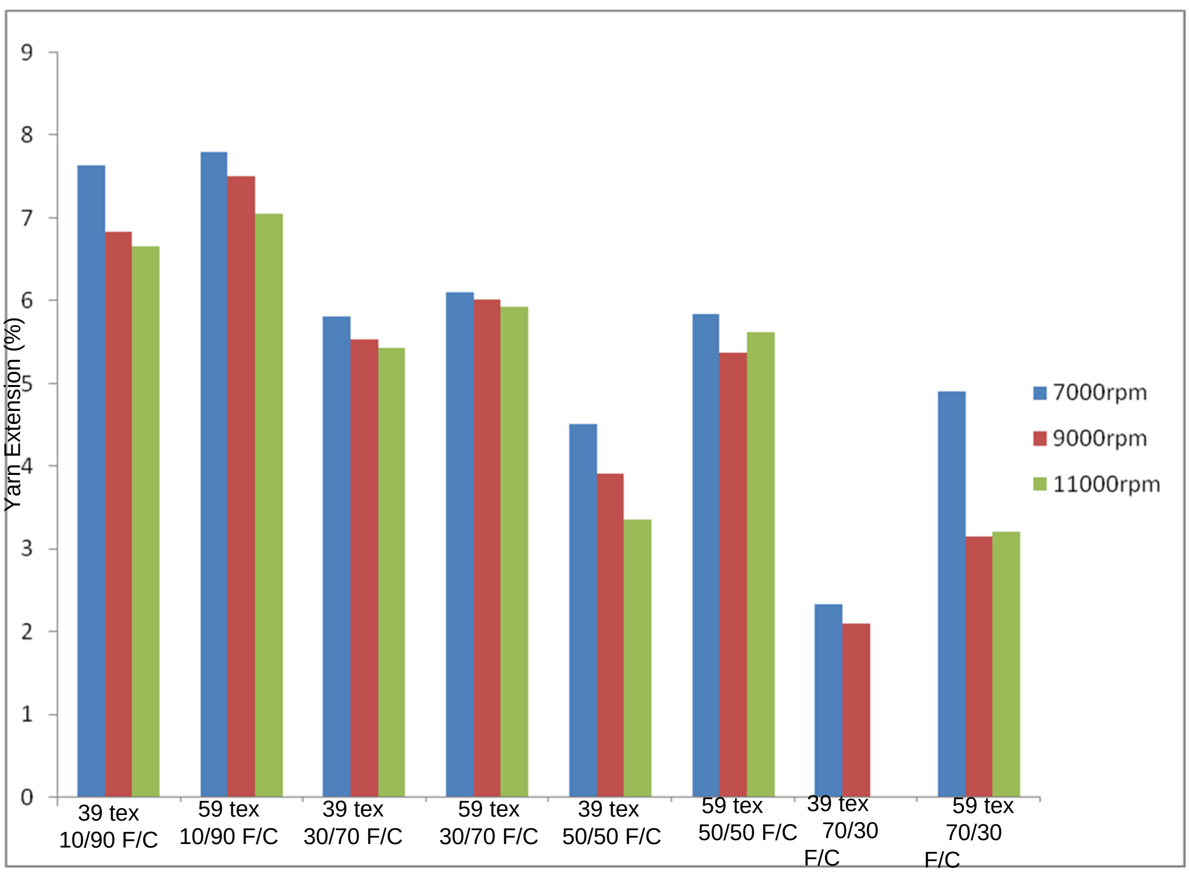

Fig. (2). Influence of spindle speed on yarn extension.

Table 3. Influence of Spindle Speed on Evenness and Imperfections of Flax/Cotton Blended Ring Spun Yarns

Blend Ratio (F/C)	Linear Density (tex)	Spindle Speed (rpm)	Um (%)	CVm (%) of Um	Imperfection Per Km			Total Imperfections Per Km	Hairiness (H)
					Thin Places (-50) Per Km	Thick Places (+50%) Per Km	Neps (+200%) Per Km)		
10/90	39	7000	12.24	15.56	11	237	176	424	6.26
		9000	12.40	15.80	10	281	189	480	6.68
		11000	12.53	15.91	15	274	204	493	6.95
	59	7000	10.44	13.60	1	58	45	104	7.22
		9000	10.84	13.80	0	52	60	112	7.54
		11000	10.90	13.87	7	62	49	118	7.81
30/70	39	7000	20.43	26.07	1351	2361	2001	5713	8.44
		9000	20.92	26.72	1731	2669	3226	7626	8.84
		11000	21.10	26.84	1792	2756	3421	7969	9.56
	59	7000	17.11	23.13	636	1439	1429	3504	8.60
		9000	17.98	23.01	807	1341	1410	3558	8.88
		11000	18.65	23.87	802	1501	1595	3898	9.08
50/50	39	7000	27.37	34.46	6254	4640	8119	19013	8.17
		9000	28.22	35.74	6790	4828	8196	19814	8.41
		11000	29.28	33.91	6817	4824	8671	20312	8.20
	59	7000	23.77	30.13	2988	2978	4269	10235	9.12
		9000	24.54	29.66	3146	3068	5122	11336	9.55
		11000	24.97	31.22	3462	3084	4979	11525	9.20
70/30	39	7000	38.51	44.65	11012	5184	8728	24924	9.06
		9000	40.10	46.32	10105	6248	10327	26680	13.01
		11000(N/P)	N/P	N/P	N/P	N/P	N/P	N/P	N/P
	59	7000	35.69	41.05	8529	4542	9263	22334	10.14
		9000	36.63	40.21	9314	5621	9475	24410	12.98
		11000	36.81	41.39	9001	6548	9517	25066	11.16

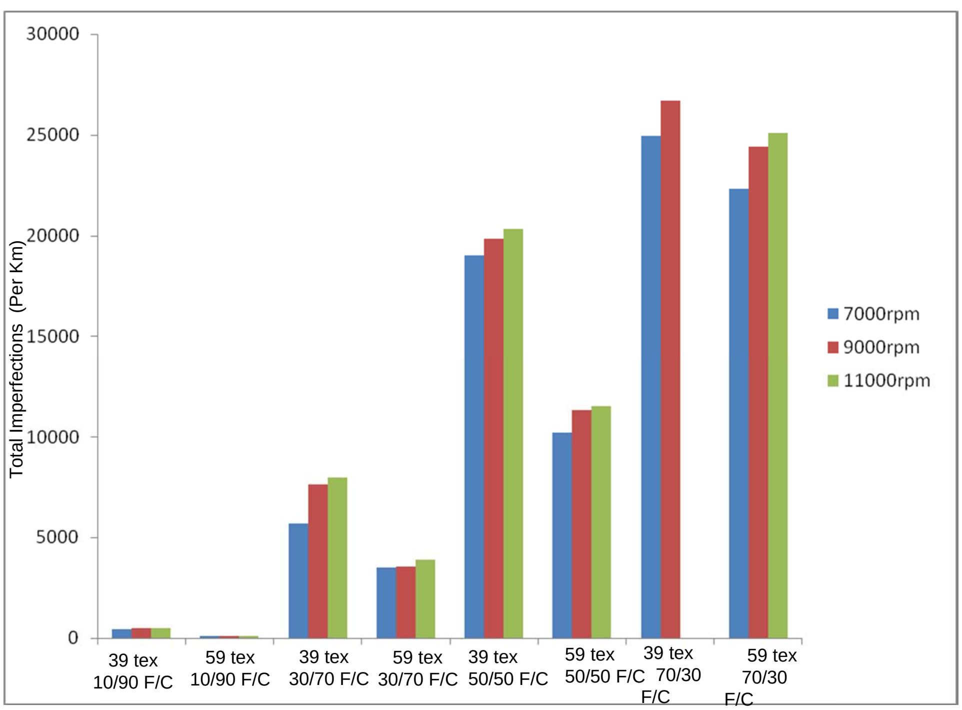

Fig. (3). Influence of spindle speed on yarn imperfections.

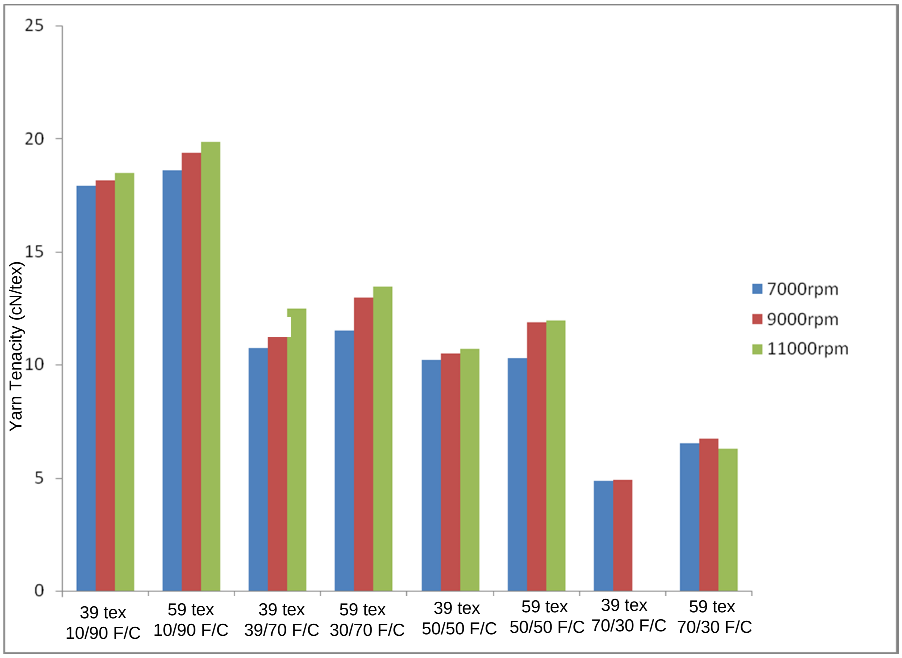

Fig. (4). Influence of spindle speed on yarn hairiness.

DISCUSSION

Table **1** shows the properties of flax and cotton fibres measured. It can be seen from Table **1** that flax is coarser than cotton. Also, Table **1** indicates that flax has higher tenacity than cotton, but the % extension of cotton is higher than that of flax. The migration behaviour of a fibre is influenced by its mean radial position in yarn. The flax fibres been the surface fibres show least tendency to migrate, while cotton fibres been the core fibres exhibit short term but low amplitude migration [8,9].

As observed from Table **2** and Fig. (**1**) as the spindle speed increases, the tenacity of flax/cotton blended yarns produced also increases. This is attributed to the fact that, as the spindle speed increases during spinning, the frictional force also increases, and this force tends to straighten the fibres in the drafting field [1]. At high drafting speed, there is an increase in tenacity, but, as the spindle speed continues to increase due to high drafting force, there will be uncontrolled movement of the fibres in the drafting field and the dragging of the fibres from the front roller nip will lead to deterioration in tenacity. Again, as the spindle speed increases, due to high tension, the yarn breakage rate increases and the machine efficiency gets affected [1,2]. Therefore, the optimum spindle speed depends on the mechanical condition of the machine and the nature of the raw material.

The breaking extension of flax/cotton blended yarns decreases as the spindle speed increases as shown in Table **2** and Fig. (**2**). Also, as the percentage of flax content in the blend increases, the breaking extension decreases. The breaking extension of 59 tex ring spun yarn is higher than that of 39 tex ring spun yarn under the same spinning conditions, due to differences in their tenacity, the former being higher than the latter.

It can be observed in Tables **2** and **3**, also in Figs. (**1**-**4**) that it was not possible to spin 39tex 70/30 flax/cotton blended ring spun yarn at a spindle speed of 11000 rpm and this was attributed to high tension and frequent yarn breakages arising from decreasing strength of the yarn.

As shown in Table **3** and Fig. (**3**), increase in spindle speed causes an increase in total imperfections (neps, thin and thick places) of flax/cotton blended yarns. As the spindle speed increases, the ratio of static to dynamic friction increases, which tends to improve the imperfections. Again, increase in drafting speed increases the average fibre tension, which results in an increase in the dragging out or pulling force exerted by the fast moving fibres. Also, at high drafting speed, there is roller vibration and the front roller nip does not remain stable, which may lead to uneven yarn [1-3]. The drafting wave is formed as a result of non-steady motion of the fibres in the drafting field. Due to the fact that the flax and cotton fibres are not of the same height, the shorter fibres (flax) are released by the back rollers before their front ends have reached the front rollers. These fibres (flax) tend to come out of the front rollers in clots and so cause alternate thick and thin places in the drafted material. At high spindle speed, more fly is deposited on the yarn due to high air current. Moreover, the higher breakage rate and irregularity associated with the high spindle speed also contributed to the occurrence of yarn faults.

It was observed from Table **3** and Fig. (**4**) that as the spindle speed increases, the hairiness of flax/cotton blended yarns also increases. This is due to the fact that at higher spindle speed, the number of floating fibres increases and the fibres tend to protrude from the body of the yarn thereby contributing to the yarn hairiness.

CONCLUSION

The tenacity and total imperfections (neps, thin and thick places) of flax/cotton blended yarns increased, whereas, the breaking extension decreased with the increase in spindle speed for all the yarn linear densities and blend proportions studied. But, the tenacity value decreased, while the total imperfections increased, as the percentage of the flax content in the flax/cotton blends increased. It was not possible to increase the spindle speed beyond 9000 rpm for 39 tex 70/30 flax/cotton blended yarn due to frequent yarn breakages. It is possible to process 50/50 flax/cotton blends at higher spindle speeds for both fine and coarse count ring spun yarns. Thus, the 10/90 flax/cotton blended yarn produced gave the best quality in terms of strength and uniformity of the yarn.

A major disadvantage with the dew-retted flax utilized in this study is the high amount of short fibres in the flax which contributed to the decrease in the quality of the blended yarns produced as the percentage of flax in the blend increased. Hence, a more uniform fibre length would lead to better yarn quality. The uniformity in fibre length can be achieved with improvements in retting systems and processing equipment.

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