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INFLUENCE OF TWIST LEVEL AND BLEND RATIO ON MECHANICAL & PHYSICAL PROPERTIES OF TENCEL/POLYESTER BLENDED RING YARNS

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ABSTRACT

The properties of ring yarns spun with two different blend ratios of 70/30 &30/70 of tencel/polyester fibres, three different twist levels and two linear densities have been studied. It is observed that increase of tencel content in the fibre mix adversely affect the yarn strength, breaking elongation, evenness, imperfections and hairiness characteristics. Further, with increase of tex twist factors, tensile strength of yarn initially increases and further increase of twist level lowers the tensile strength. While, the yarn characteristics like breaking elongation, mass irregularities, imperfections and flexural rigidity increases with increase of twist factors. Again, hairiness of both types of blended yarns continues to decrease with increase of twist level.

INTRODUCTION

Blending is a well established technique, which is used in industries to suit the end product requirement such as functional or desirable properties along-with cost optimisation. The blending of natural as well as regenerated cellulosic fibres with polyester is the most common employed practice for balancing the limitations of both the fibres. Tencel, is one of the new entrant in the family of regenerated cellulosic fibres & is produced by lyocell process using N-methylmorpholine N-oxide as a spinning solution reagent [1]. Like other cellulosic fibres textile substrates of tencel are breathable, absorbent, permeable, and comfortable to wear and fair resiliency and fewer creases. Along with these properties its strength is comparable to typical staple fibre of polyester and better than cotton fibre. It also exhibit better wet strength and modulus than conventional viscose fibre this makes its spinning, weaving, dyeing, finishing & laundering trouble free. Tencel can be blended well together with wool, silk, viscose, cotton, linen and polyester and enhance the desirable & functional characteristics of blended yarns and fabrics [2-4]. Even though there were many studies which emphasize the pros and cons of tencel fibre. However, the published work related to characteristics of tencel blended yarns and fabrics are very limited. Therefore, this study is seeking to explore the characteristics features of tencel-polyester blended ring-yarns spun with different tex twist factors.

MATERIALS AND METHODS

Materials

Fibres

The tencel and polyester fibres were used in the present study. The specifications and stress-strain diagrams of tencel and polyester fibres are given in Table 2.1 and Fig. 2.1 respectively. In both fibres, polyester is stronger and more extensible, while tencel has higher initial modulus.

TABLE 2.1 SPECIFICATIONS OF TENCEL AND POLYESTER FIBRES

Fibre Type / Fibre Properties	Length (mm)	Linear Density (dtex)	Tenacity (cN/tex)	Breaking Elongation (%)	Modulus (cN/tex)
Tencel	38	1.40	29.63	7.04	451.58
Polyester	38	1.40	54.51	14.15	300.14

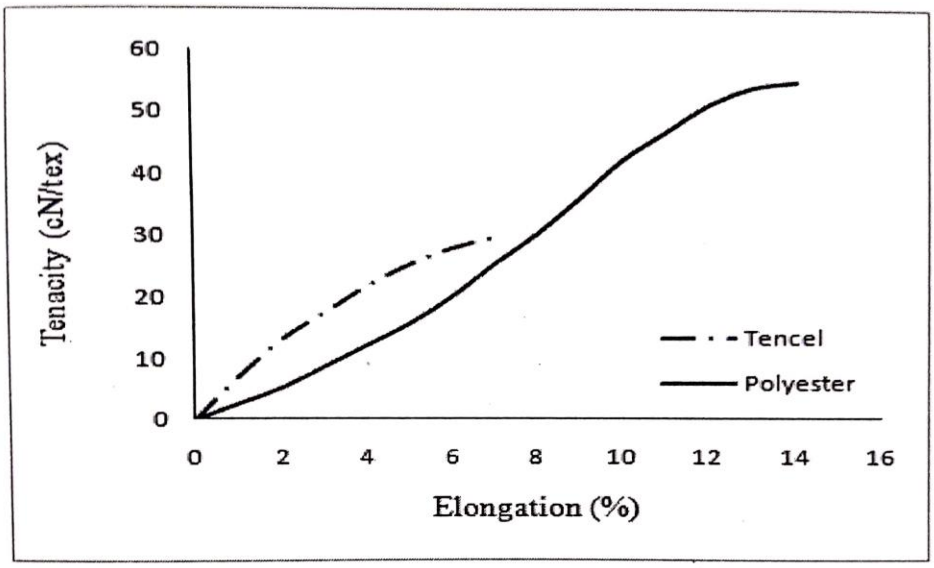

Fig. 2.1-Stress -strain curve of tencel and polyester fibre

Preparation of Yarn Samples

Tencel and polyester fibres were blended to spun ring yarns with 19.6 tex & 29.5 tex linear densities using two blend ratios (30:70 & 70:30) with three different tex twist factors 33.46, 38.25 and 43.02. For well mixing and blending of tencel and polyester fibres, a predetermined quantity of both fibres were manually mixed two times and then processed in a Trutszler blow-room line for homogeneous blend. The conversion to sliver was carried out by using a LR C-1/3 carding machine. Two drawing passages were given to the card sliver and for this LMW LDO/6 as breaker draw-frame and finisher draw-frame LRSB 851 were used, the linear density of finisher sliver being adjusted to 4.217 ktex. The finisher sliver to roving of 513 tex was converted on a LMW LFS 1660 simplex, which was used to produce 19.6 tex & 29.5 tex yarns on LMW LR6/S ring frame using a spindle speed of 283.33 rotations per second.

TEST METHODS

Fibre Test

Performance of a yarn in its subsequent processes is influenced by its strength and elongation, and both yarn properties strongly affect by its constituent fibre's strength and elongation. Lenzing's vibrodyn tester was used to measure the single fibre tenacity, breaking extension and initial modulus as per ASTM (3822-07) standard. The stress strain curve was also obtained for both fibres. For the measurement, single fibres were carefully separated from the bundles and both fibre ends were clamped pneumatically between two jaws at a predetermined tension. The gauge length was kept 20 mm for testing the fibre properties. The tests were conducted on constant rate of elongation principle. The lower jaws were traversed at constant rate while upper jaws were attached to a sensitive load cell. Twenty observations were taken for each sample.

Yarn Test

All the yarns were tested for single strand strength and breaking extension on Uster Tenso Rapid-3 (UTR-3) according to ASTM (D2256) standard. The yarn sample is clamped between two jaws with upper jaw connected to load cell and lower jaw is traversed downwards at a constant rate of traverse.

Mass irregularity and imperfections of both types of yarns were recorded according to ASTM standards (D 1425/1425M-09) by Uster Evenness Tester-3 (UT-3). The yarn is passed between two capacitance plates at a constant speed. The capacitance of the condenser varies according to weight per unit length of yarn. The variations in capacitance are converted into voltage and amplified. A continuous record of variations is obtained in a recorder chart. Instantaneous values of Mean Deviation % (U %) or Coefficient of variation (CV %) of the variations is computed by an integrator and displayed. UT-3 was also used for determining yarn imperfection, like thick places, thin places and neps on the basis of their sizes.

All the yarn samples were tested for flexural rigidity on weighted ring yarn stiffness tester by ring loop method [10]. For each yarn sample, fifty observations were taken. The steam setting was given to all yarn samples for 15 minutes before testing to yarns samples, yarns were very twist lively and it was very difficult to make a loop without distortion and deformations.

(IJAER) 2011, Vol. No. 2, Issue No.VI, December ISSN: 2231-5152

Flexural rigidity was calculated with the help of Riding and Owens table [10].

$$G = {ML^2}/{Z}\ gcm^2$$

Where, M = Mass of rider, gm
Z = Table value of non-dimensional load corresponding to value of d_1/L
L =Length of loop, cm
d_1=Deflection in cm produced by weight 'M'

Zweigle hairiness meter (Model G565) based on photoelectric principle was used to measure yarn hairiness (ASTM D5647-01). The projecting fibers interrupt a light beam and a variation in the intensity of light received by photocell. The hairs of varying projected length (perpendicular length of protruding hair to yarn axis from yarn surface) emerging from a yarn from a length of 1 mm to 25 mm were counted by means of a sequence of photoelectric cells placed behind the yarn core.

RESULTS AND DISCUSSION

Tenacity

Table 4.1 and figure 4.1 show the results of tensile tests of tencel-polyester blended ring spun yarns with varying twist levels and blend composition. The results show a considerable difference in tenacity of yarns spun with different twist factors. Tencel-polyester ring yarn shows an increase in strength when tex twist factors varies from 33.46 to 38.25, but further increase in twist factor to 43.02, a decrease in strength is noticed. The initial increase in yarn tenacity with increase in twist factor is attributed to the effect of improvement in fibre friction which prevails over the effect of inclination to the yarn axis, however, a further increase in fibre friction due to twist is overcome by the decrease in contribution by the component of fibre strength in yarn axis direction and results in overall reduction of yarn tenacity [5, 6].

While the increase in tencel content in blend, yarns of both linear densities exhibit a significant reduction in their strength, it is because of lower strength of tencel in comparison to polyester [2, 4]. Again for all twist factors and blend ratios coarser yarn shows higher tenacity than its finer yarn counterpart, it is obviously doe to a greater number of fibres in the ring yarn cross-section.

Table 4.1: Influence of Blend Ratio and Tex Twist Factor on Tenacity cN/Tex of Tencel/Polyester* Blended Ring Spun Yarns

Yarn Linear Density	Blend Ratio	Tenacity cN/Tex		
		TF_1	TF_2	TF_3
19.6 Tex	30/70*	28.33	28.82	26.68
	70/30*	17.61	19.07	18.04
29.5 Tex	30/70*	29.95	30.09	28.28
	70/30*	20.2	20.07	19.49

Tex Twist Factor
TF_1- 33.46, TF_2- 38.25, TF_3- 43.02

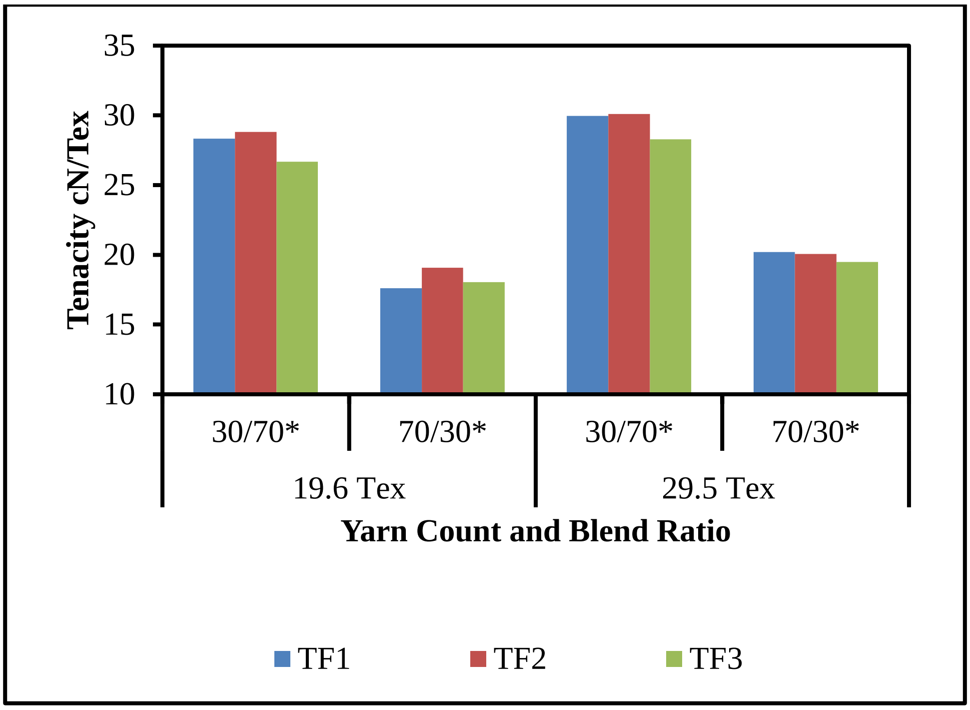

Fig. 4.1-Variation in tenacity with increase of tencel content in fibre-mix of tencel/polyester* blended ring yams spun at different tex twist factors.

Breaking Elongation

As expected, the yarns containing high polyester content in the blends exhibit higher breaking elongation than their equivalent opposite blend obviously it is due to higher breaking elongation of polyester [2].

The breaking elongation of all yarn samples of both fibre mix increases from 6.85% to 11.22% with increase in twist factor from 33.46 to 43.02. For both fibre-mix, the breaking elongation increases with increase in twist factor on account of spirality of fibres. As level of twist rises, a close spiral path is followed by the constituent fibre within the yarn. When such yarns are allowed to stretch, the spiral extends at first, instead of the fibres. This causes more and more extension of the yarns with increase in twist factor. Also increase in twist factor increases the inter-fibre cohesion which also majorly contributes in breaking elongation [8]. Further with increase of yarn linear density also exhibit higher breaking elongation due to more fibres across yarn as well as longer spiral path is followed by fibres in coarser yarns.

Influence of Fibre Composition and Tex Twist Factor on Breaking Elongation (%) of Tencel-Polyester* Blended Ring Spun Yarns

Yarn Linear Density	Blend Ratio	Breaking Elongation (%)		
		TF_1	TF_2	TF_3
19.6 Tex	30/70*	9.75	9.97	10.06
	70/30*	6.85	7.14	7.29
29.5 Tex	30/70*	10.56	11.14	11.22
	70/30*	8.2	8.32	8.46

Tex Twist Factor
TF_1- 33.46, TF_2- 38.25, TF_3- 43.02

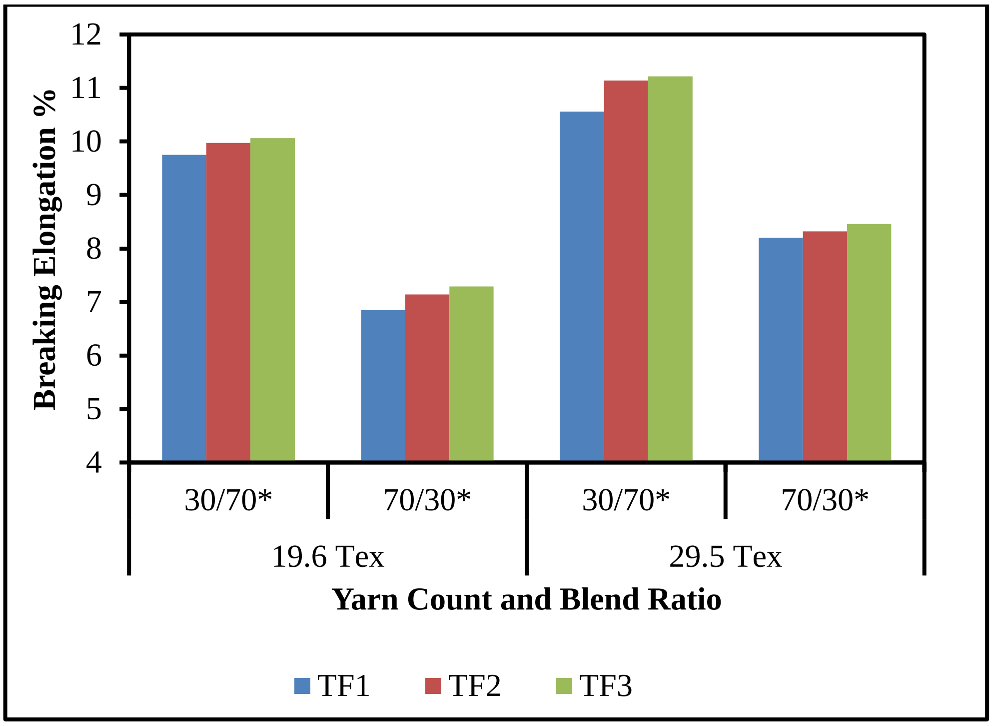

Fig. 4.2 —Variation in breaking elongation with increase of tencel content in fibre-mix of tencel-polyester* blended ring yams spun at different tex twist factors.

Mass irregularity (U %)

Mass irregularity (U %) of tencel-polyester blended ring yarns, spun with different twist factors, is shown in table 4 .3 and unevenness of ring yarns vary from 9.61% to 16.25%.

As expected, evenness of yarns is influenced by varying twist factors. As the twist increases, ring yarn exhibit a decreasing trend of evenness. With increase in twist factor the drafting speed reduces, as increase of twist is carried out by reducing front roller delivery speed. The decrease in drafting speed lowers the inter fibre friction which essentially controls the movement of floating fibres at the time of sudden acceleration in drafting field. Hence, a decline in evenness is observed when twist factor is increased [7].

There was a different trend of evenness is observed with increased tencel content. As the tencel content increases the cluster value of yarn increases. The abrupt rise of unevenness about 30% to 50% is observed with increased tencel fibre content for both linear yarn densities. It is due to fibrillar nature of tencel. Fibrillation means fibre longitudinally splits in micro fibres [4], which ultimately creates undue entanglement between adjacent fibres during drafting and reduces the control on moving fibres in drafting fibres. Therefore, steep rise in unevenness is noticed. Further, Mass irregularity in coarser yarns is found to be less than their fine yarn counterparts. It is the result of higher number of fibres in the yarn cross-section.

Table-4.3 Influence of Fibre Composition and Tex Twist Factor on Mass Irregularity (U %) of Tencel-Polyester* Blended Ring Spun Yarns

Yarn Linear Density	**Blend Ratio**	**Mass Irregularity (U %)**		
		TF_1	TF_2	TF_3
19.6 Tex	**30/70***	11.78	12.12	12.22
	70/30*	15.28	15.67	16.25
29.5 Tex	**30/70***	9.61	9.82	9.96
	70/30*	14.71	14.88	15.33

Tex Twist Factor
TF_1- 33.46, TF_2- 38.25, TF_3- 43.02

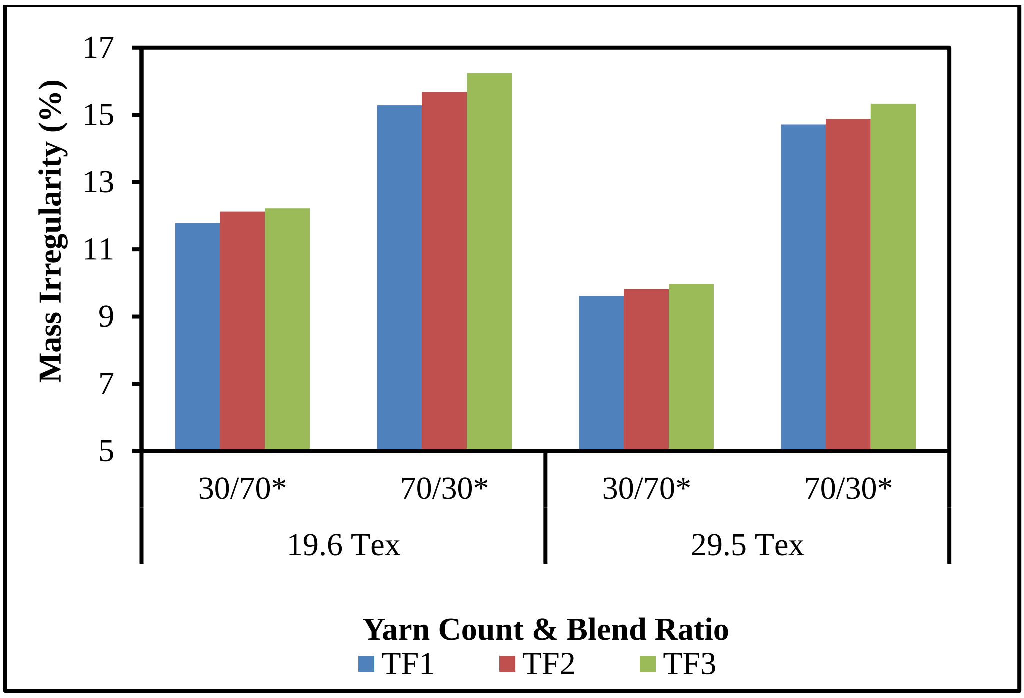

Fig. 4.3—Variation in Mass Irregularity with increase of tencel content in fibre-mix of tencel-polyester* blended ring yams spun at different tex twist factors.

Imperfections

From table 4.4 and fig. 4.4, the results of imperfection in yarns is observed and found the effect of twist level and constituent fibre. The imperfections/km, particularly thick places and neps for both linear density yarns, a abrupt rise is noticed with increase of tencel content in the fibre mix. The main cause of this sudden increase in imperfections is the fibrillar nature of tencel [4] and in addition to this some fibres in the form of bunches were also gone with yarn from drafting zone and may be counted as thick place or neps. Again, as the twist increases, an increase in imperfection is observed. This result is the consequence of increase in twist level decreases the front roller delivery speed and reduces the inter fibre friction in the drafting field. This lowers the control on floating fibres and enhances the imperfections [7]. Further, the finer yarns show higher number of imperfections than their equivalent coarser yarns. It is due to a smaller number of fibres in cross section of yarn as well as better processing control.

Table-4.4-Influence of Fibre Composition and Tex Twist Factor on Thin, Thick, Neps and Imperfections of Tencel-Polyester* Blended Ring Spun Yarns

Yarn Linear Density	Blend Ratio	Thin Places			Thick Places			Neps			Total Imperfections		
		TF_1	TF_2	TF_3	TF_1	TF_2	TF_3	TF_1	TF_2	TF_3	TF_1	TF_2	TF_3
19.6 Tex	**30/70***	2	2	4	26	16	12	187	223	272	215	241	288
	70/30*	5	8	9	69	52	46	626	714	816	700	774	870
29.5 Tex	**30/70***	0	0	0	9	6	6	31	38	49	40	44	55
	70/30*	0	0	0	31	28	22	152	229	287	183	257	309

Tex Twist Factor

TF_1- 33.46, TF_2- 38.25, TF_3- 43.02

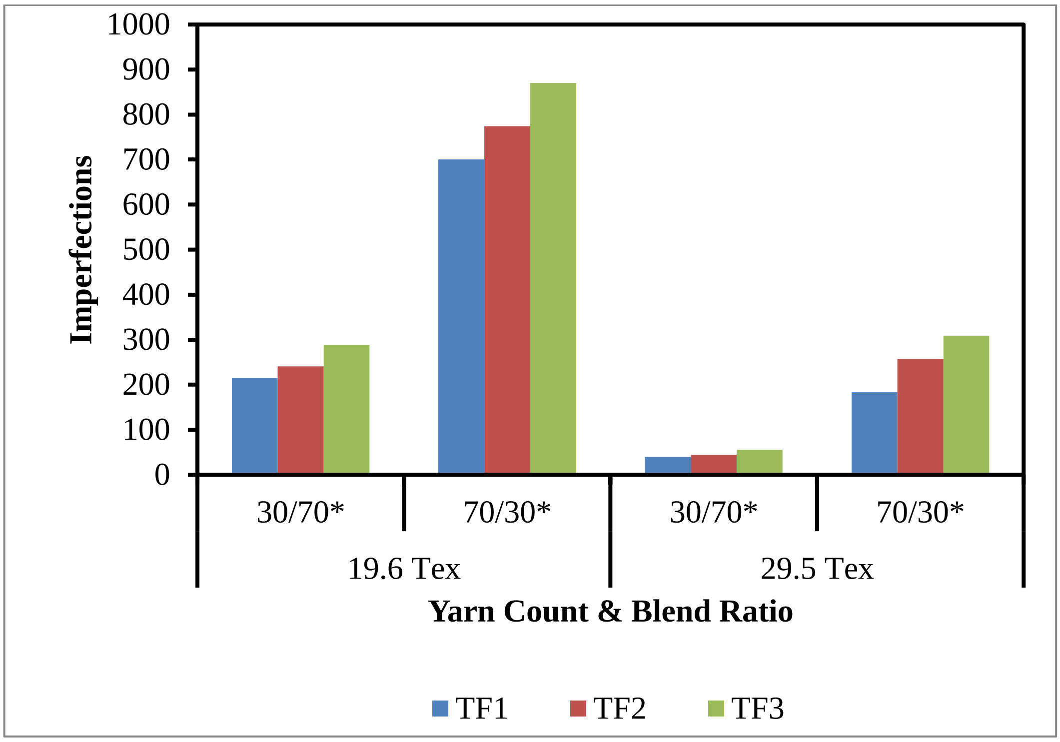

Fig. 4.4—Variation in Imperfections with increase of tencel content in fibre-mix of tencel-polyester* blended ring yams spun at different tex twist factors.

Flexural Rigidity

Flexural rigidity of a spun yarn depends upon its structure and constituent fibres[10]. As the tencel content increases in the blend composition of yarns show an increase in flexural rigidity, it is due to high initial modulus (see stress-strain curve fig. 2.1) and flexural rigidity of tencel fibre [2,9].

Twist level considerably affect the flexural rigidity of ring yarns. However as the twist factor increases flexural rigidity also increases due to improvement in packing density of yams which increase the fibre to fibre cohesion and hampers the free movement of fibres. Again, coarser yarns show slightly higher value of flexural rigidity due to a greater number of fibres in the cross section which increase the resistance to bend of fibre assembly.

Table-4.5-Influence of Fibre Composition and Tex Twist Factor on Flexural Rigidity × (10^{-3} Gm.Cm^2) of Tencel-Polyester* Blended Ring Spun Yarns

Yarn Linear Density	Blend Ratio	Flexural Rigidity ×(10^{-3} gm.cm^2)		
		TF_1	**TF_2**	**TF_3**
19.6 Tex	**30/70***	3.14	3.26	3.37
	70/30*	4.43	4.57	4.60
29.5 Tex	**30/70***	3.19	3.38	3.48
	70/30*	4.56	4.74	4.82

Tex Twist Factor
TF_1- 33.46, TF_2- 38.25, TF_3- 43.02

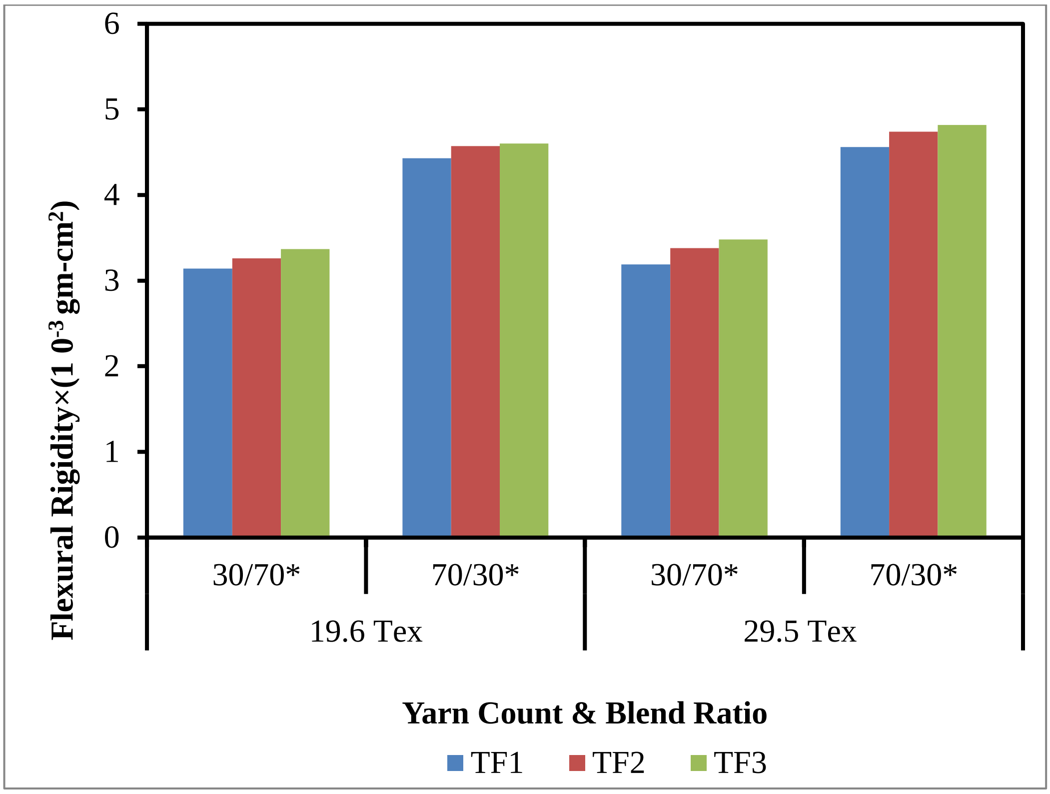

Fig. 4.5 —Variation in Flexural Rigidity with increase of tencel content in fibre-mix of tencel-polyester* blended ring yams spun at different tex twist factors.

Hairiness

A quick look on hairiness results in table 4.6 discloses that the blend component and twist level have considerable effect on protruding fibres. In case of tencel majority in the blend, the yarns exhibit higher number of protruding fibres on yarn surface particularly short hairs, due to higher flexural and torsional rigidity of tencel fibre[4]. On comparing the coarser and finer yarns of both blends, the coarser yarn shows significantly higher number of hairs on the yarn surface because o f higher number of fibres in the yarn cross-section.

Furthermore, an increase in twist level of all yarns, a decrease in yarn hairiness index was noticed due to variation in fibre migration behaviour. High twist level force to migrates the fibres towards the yam axis and firmly bind them within yarn body. Low spinning triangle is also a partly cause of the decline of hairiness of ring yarn on the increase of twist factor [6].

(IJAER) 2011, Vol. No. 2, Issue No.VI, December ISSN: 2231-5152

Table 4.6:- Influence of Fibre Composition and Tex Twist Factor on Hairiness (Hairs/10cm) of Tencel-Polyester* Blended Ring Spun Yarns

Yarn Linear Density	Blend Ratio	Hairs ≥ 1mm			Hairs ≥ 2mm			Hairs ≥ 3mm (S_3)		
		TF_1	TF_2	TF_3	TF_1	TF_2	TF_3	TF_1	TF_2	TF_3
19.6 Tex	30/70*	743	672	623	62	57	50	43	36	32
	70/30*	2639	1007	1111	124	94	97	60	53	50
29.5 Tex	30/70*	1674	1309	1268	163	137	134	56	49	46
	70/30*	2015	1721	1750	184	151	135	71	67	64

Tex Twist Factor
TF_1- 33.46, TF_2- 38.25, TF_3- 43.02

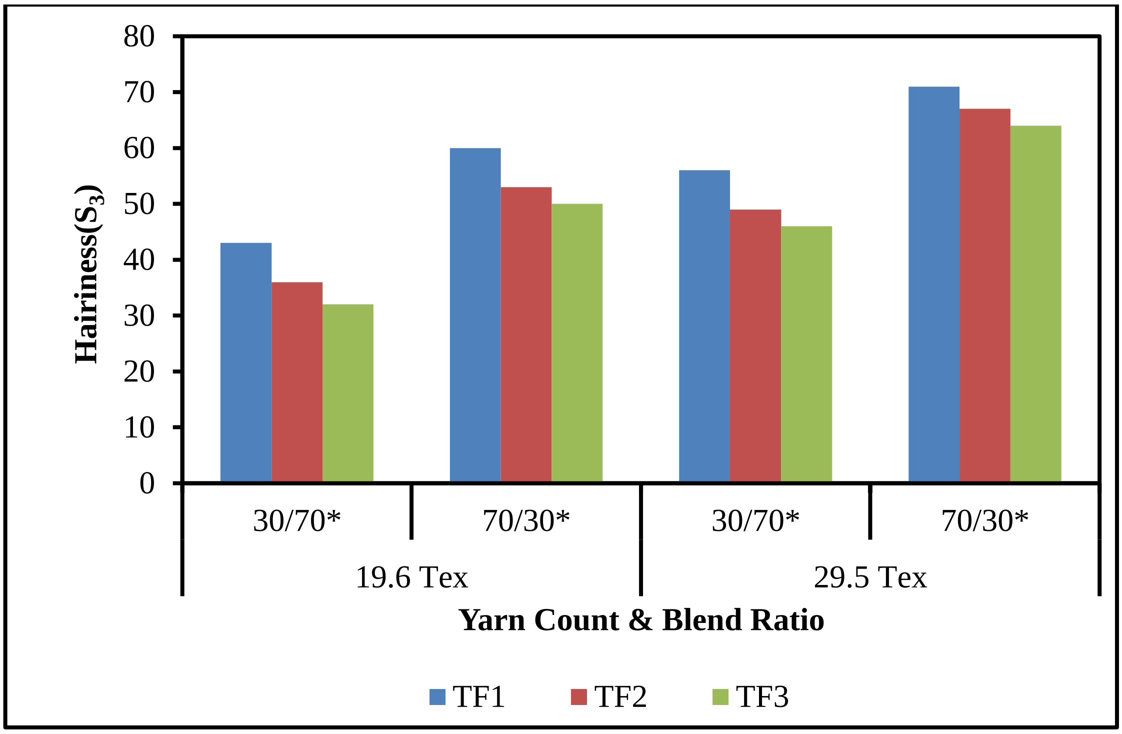

Fig. 4.6 —Variation in Hairiness with increase of tencel content in fibre-mix of tencel-polyester* blended ring yams spun at different tex twist factors.

CONCLUSIONS

- Tensile properties of tencel-polyester blended ring yarns are greatly influenced by variation in fibre composition and tex twist factor. As the tencel content increases in the blend ratio, yarns of both linear densities show a significant reduction in their strength, breaking extension. However, yarns spun at 38.25 tex twist factor show maximum strength and followed a decreasing trend with further increase in twist level. In addition to this, both types of yarns show an increase in breaking extension with the increase of twist factor. Furthermore, for all twist factors and blend ratios coarser yarn shows slightly higher tenacity than its finer yarn counterpart.

- Ring yarns show an abrupt increase in mass irregularity and imperfections (particularly thick places and neps) with the increase of tencel content in the fibre mix. It is due to fibrillar nature of tencel which enhances the fibre entanglement in drafting zone and reduces the effective control on moving fibres. However, an increase in twist factor, a rise in unevenness and imperfections in yarns is observed, obviously it is due to reduction in inter fibre friction with rise in twist level.
- Tencel majority yarns exhibit more flexural rigidity than polyester majority yarns, due to higher initial modulus and bending rigidity of tencel fibre. While an increase in twist factor enhances the flexural rigidity of all the yarns.
- Hairiness value (S_3) increases with increase of tencel content in the fibre mix, it is caused by higher flexural rigidity of tencel. Also hairiness of all yarns reduces with the increase of twist factor, as rise in twist level results in reduction size of spinning triangle and also migrate the fibres towards the yam axis and firmly binds them within yarn body.

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