

MECHANICAL AND PHYSICAL PERFORMANCE ANALYSIS OF POLYESTER/MODAL BLENDED YARNS PRODUCED BY RING AND COMPACT SPINNING SYSTEMS

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ABSTRACT

This study systematically investigates the influence of fibre composition and tex twist factor on the mechanical and physical properties of polyester/modal blended yarns produced using conventional ring and compact spinning systems. Polyester and modal fibres were blended in three proportions (70/30, 50/50, and 30/70) and spun into 19.6 tex yarns at three tex twist factors (28.71, 33.50, and 38.28). The yarns were evaluated for tensile properties, mass irregularity, imperfections, hairiness, diameter, and shrinkage. The results demonstrate that both blend ratio and twist factor significantly affect yarn performance. Compact-spun yarns consistently exhibited superior mechanical and physical properties compared to conventional ring-spun yarns, primarily due to improved fibre alignment, higher packing density, and reduced spinning triangle. Yarn tenacity increased with twist factor up to an optimum level, beyond which further twist insertion led to a reduction in strength due to increased fibre obliquity and structural rigidity. Increasing modal content in the blend adversely affected tensile strength, uniformity, and overall yarn quality in both spinning systems, whereas higher polyester proportions enhanced strength and dimensional stability. Overall, polyester-rich compact-spun yarns produced at optimal twist levels demonstrated the most favourable balance of strength, uniformity, and structural compactness.

Keywords: *Polyester; Modal; Ring Spinning; Compact Spinning; Blend Ratio; Twist Factor*

INTRODUCTION

Blending of fibres has long been practiced in the textile industry to combine the desirable properties of different fibres and to overcome their individual limitations. Among synthetic fibres, polyester is widely used due to its high strength, excellent durability, dimensional stability, and good resistance to abrasion and chemicals. Its relatively high tenacity and superior elongation

characteristics make it particularly suitable for producing yarns with enhanced mechanical performance. However, polyester fabrics often exhibit lower moisture absorbency, reduced comfort, and inferior softness compared to cellulosic fibres [1, 2].

Modal fibre, a regenerated cellulosic fibre derived from beechwood pulp, has gained considerable attention as a blending partner due to its high moisture regain, softness, smooth handle, and superior drape characteristics. Compared to conventional viscose, modal exhibits improved wet strength, better dimensional stability, and enhanced uniformity [3, 4]. Its relatively high modulus and smooth surface contribute to improved fabric comfort and aesthetic appeal. However, modal fibres possess lower tenacity and breaking extension compared to polyester, which may limit their mechanical performance when used alone. Therefore, blending modal with polyester offers the potential to produce yarns that combine the strength and resilience of polyester with the comfort and moisture management properties of modal.

In addition to fibre composition, spinning technology plays a crucial role in determining yarn structure and performance. Conventional ring spinning remains the most widely used spinning system due to its versatility and ability to produce high-quality yarns. However, the presence of the spinning triangle in ring spinning often leads to fibre migration, increased hairiness, and higher unevenness. Compact spinning, an advanced modification of ring spinning, addresses these limitations by eliminating or significantly reducing the spinning triangle through fibre condensation prior to twist insertion [5]. This results in improved fibre alignment, higher packing density, reduced hairiness, and enhanced tensile properties [8]. Despite extensive research on polyester and modal blends individually, limited systematic studies have comparatively evaluated their performance in both ring and compact spinning systems under varying twist levels.

Twist factor is another critical structural parameter influencing yarn performance. Twist binds fibres together, enhances inter-fibre friction, and improves strength up to an optimum level. Beyond this level, excessive twist increases fibre obliquity and structural rigidity, leading to deterioration in tensile properties [6, 7]. The interaction between fibre composition and twist level, particularly in blended yarns produced by different spinning systems, requires comprehensive investigation to optimize yarn quality.

Therefore, the primary aim of this research is to evaluate the mechanical and physical properties of polyester/modal blended yarns produced by ring and compact spinning systems. Specifically,

the study investigates the influence of blend ratio (70/30, 50/50, and 30/70 polyester/modal) and tex twist factor (28.71, 33.50, and 38.28) on key yarn characteristics, including tenacity, breaking extension, mass irregularity, imperfections, hairiness, diameter, and shrinkage. By systematically analyzing the combined effects of fibre composition, twist factor, and spinning technology, this work seeks to identify the optimal blend and structural parameters for achieving improved yarn performance suitable for high-quality textile applications.

MATERIAL AND METHODS

Yarn samples separation

For the present investigation, polyester and modal staple fibres of identical staple length (38 mm) and linear density (1.2 dtex) were selected to ensure compatibility during blending and spinning. The polyester fibres possessed a tenacity of 56.69 cN/tex and a breaking extension of 16.43%, whereas modal fibres exhibited a tenacity of 30.76 cN/tex and a breaking extension of 6.69%. The comparable fibre length and fineness enabled uniform blending and minimized drafting irregularities during yarn formation. Ring and compact spun yarns were prepared using three different blend ratios of polyester/modal (70/30, 50/50, 30/70) at three different level of tex twist factors of 28.71, 33.50 and 38.28.

Blending was carried out in a Trützschler blow room line, where both fibre components were thoroughly opened and homogenized to achieve uniform fibre distribution. The blended material was processed through an LR C-1/3 carding machine to produce card sliver, followed by drafting on a breaker draw frame (LMW LDO/6) and a finisher draw frame (LRSB 851). The linear density of the finisher draw frame sliver was maintained at 5.27 ktex to ensure consistent input material for subsequent processing stages.

The finisher sliver was converted into roving of 649 tex using an LMW LFS-1600 speed frame (fly frame). For each blend ratio, 19.6 tex yarns were spun at the specified tex twist factors on a Lakshmi Rieter LR 6/S ring frame to produce conventional ring-spun yarns. Comparative compact-spun yarns were manufactured on an LMW LR6/5 ring frame equipped with the Suessen Elite compact system, which employs an aerodynamic compacting.

Yarn tests

All yarn samples were evaluated for tensile properties, evenness, hairiness, diameter, and shrinkage using standardized testing procedures. Single-end breaking strength and breaking extension were measured on an Uster Tenso Rapid-4 (UTR-4) in accordance with ASTM D2256. The gauge length was set at 500 mm, and the rate of extension was adjusted to ensure a specimen break time of 20 ± 2 seconds. For each yarn variant, tensile results were averaged from 50 individual tests to ensure statistical reliability.

Mass irregularity (U%) and imperfection index (thin places, thick places, and neps) were determined using an Uster Evenness Tester-5 (UT-5) as per ASTM D1425M-14. Yarn hairiness (S_3) was measured using a Zweigle Hairiness Meter (Model G565). Hairiness testing was conducted at a delivery speed of 50 m/min for duration of 4 minutes, and the reported values represent the average of ten readings.

Yarn diameter was measured using a projection microscope to assess structural compactness. Yarn shrinkage (%) was determined in accordance with ASTM D2259-96 to evaluate dimensional stability. All tests were conducted under standard atmospheric conditions to ensure consistency and reproducibility of results.

RESULTS AND DISCUSSION

Tenacity

The tenacity results clearly demonstrate that fibre composition, tex twist factor, and spinning system significantly influence the tensile performance of polyester/modal blended yarns. For ring-spun yarns, tenacity initially increased with increasing twist factor from 28.71 to 33.50, followed by a noticeable decline at 38.28 for all blend ratios. The initial improvement in strength can be attributed to enhanced fibre cohesion and improved inter-fibre friction at moderate twist levels, which promotes efficient stress transfer among fibres. However, at higher twist levels, increased fibre obliquity reduces the axial component of fibre strength, resulting in decreased tenacity [7, 9].

Further, fibre composition had a pronounced and consistent effect on yarn strength. Across all twist levels and both spinning systems, as the modal content increases, tenacity of both types of yarns decreases. These results reflect the superior strength and higher breaking extension of

polyester fibres compared to modal fibres. Increasing polyester content enhances load-bearing capacity and improves stress distribution within the yarn structure, whereas higher modal content reduces overall tensile performance due to its comparatively lower strength and elongation.

Compact-spun yarns demonstrated significantly higher tenacity than ring-spun yarns at all blend ratios and twist factors. The superior strength of compact yarns can be attributed to improved fibre alignment, reduction of the spinning triangle, and higher packing density, which achieved through the aerodynamic compacting system [10]. These structural advantages enable more efficient stress transfer during tensile loading. Although compact yarns also exhibited a reduction in tenacity at the highest twist factor (38.28), the strength values remained consistently higher than those of ring yarns. This indicates that compact spinning enhances the effectiveness of twist insertion and produces a more structurally stable yarn. Overall, tenacity is strongly influenced by blend ratio and twist factor, with an optimum twist level observed at 33.50 for both spinning systems. Polyester-rich compact-spun yarns demonstrated the highest tensile performance, confirming that both fibre mechanical properties and spinning technology play critical roles in determining yarn strength.

Table:-1 - Influence of Fibre Composition and Tex Twist Factor on Tenacity (cN/tex) of Polyester/Modal Blended Ring and Compact Spun 19.6 Tex Yarns

Tex Twist Factor	Ring Spun			Compact Spun		
	Polyester /Modal			Polyester /Modal		
	70/30	50/50	30/70	70/30	50/50	30/70
28.71	28.52	23.14	18.90	30.15	26.67	21.57
33.50	28.93	24.05	19.17	30.99	26.89	21.81
38.28	25.97	21.92	17.97	27.85	23.46	19.90

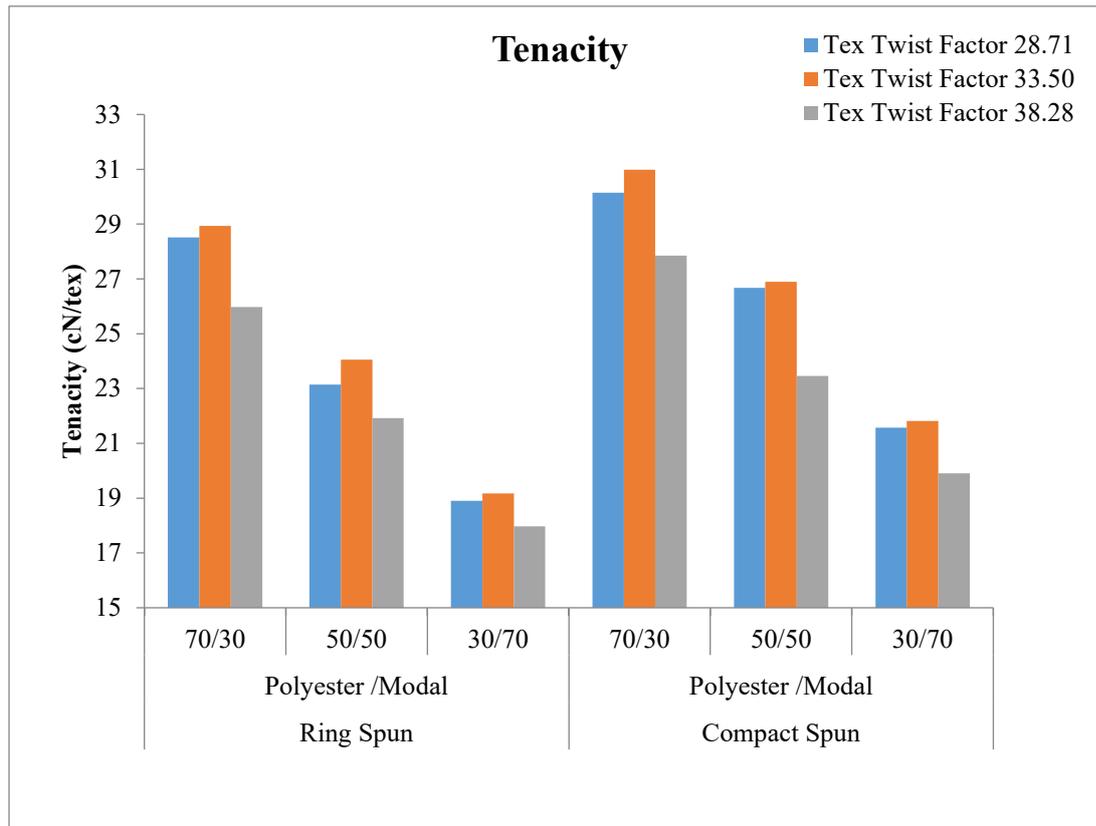


Figure:-1- Influence of Fibre Composition and Tex Twist Factor on Tenacity (cN/tex) of Polyester/Modal Blended Ring and Compact Spun 19.6 Tex Yarns

Breaking extension

The breaking extension (%) of polyester/modal blended yarns was significantly influenced by both fibre composition and tex twist factor, with noticeable differences between ring and compact spinning systems. In ring-spun yarns, breaking extension increased gradually with increasing twist factor for all blend ratios. For the 70/30 (Polyester/Modal) blend, extension increased from 8.39% at a twist factor of 28.71 to 8.62% at 38.28. A similar trend was observed for the 50/50 and 30/70 blends. The increase in extension with higher twist can be attributed to improved fibre cohesion and binding, which allows better stress distribution among fibres during tensile loading.

Fibre composition exhibited a pronounced effect on breaking extension. Both type of yarns with higher polyester content consistently showed higher elongation compared to modal-rich blends. This behaviour is directly related to the intrinsic properties of the fibres: polyester possesses higher breaking extension compared to modal.

Compact-spun yarns demonstrated substantially higher breaking extension than ring-spun yarns across all blend ratios and twist factors. The improved elongation in compact yarns can be attributed to better fibre alignment and close packing of fibres, which results in a more uniform stress transfer mechanism during tensile loading. The compact structure allows fibres to participate more effectively in load sharing before rupture, thereby enhancing extension at break.

The influence of twist factor was more pronounced in compact yarns compared to ring yarns. Increasing twist factor enhanced fibre cohesion and packing density, enabling higher strain accommodation before failure. However, within the studied range, no decline in extension was observed at the highest twist level, suggesting that the twist levels were within the optimal range for extensibility enhancement. Overall, the results indicate that breaking extension is positively correlated with polyester content and twist factor, while the compact spinning system significantly enhances extensibility compared to conventional ring spinning.

Table:-2 - Influence of Fibre Composition and Tex Twist Factor on Breaking Extension (%) of Polyester/Modal Blended Ring and Compact Spun Yarns

Tex Twist Factor	Ring Spun			Compact Spun		
	Polyester /Modal			Polyester /Modal		
	70/30	50/50	30/70	70/30	50/50	30/70
28.71	8.39	7.04	6.39	9.82	8.37	6.92
33.50	8.57	7.25	6.54	10.54	8.97	7.17
38.28	8.62	7.40	6.83	11.01	9.52	7.83

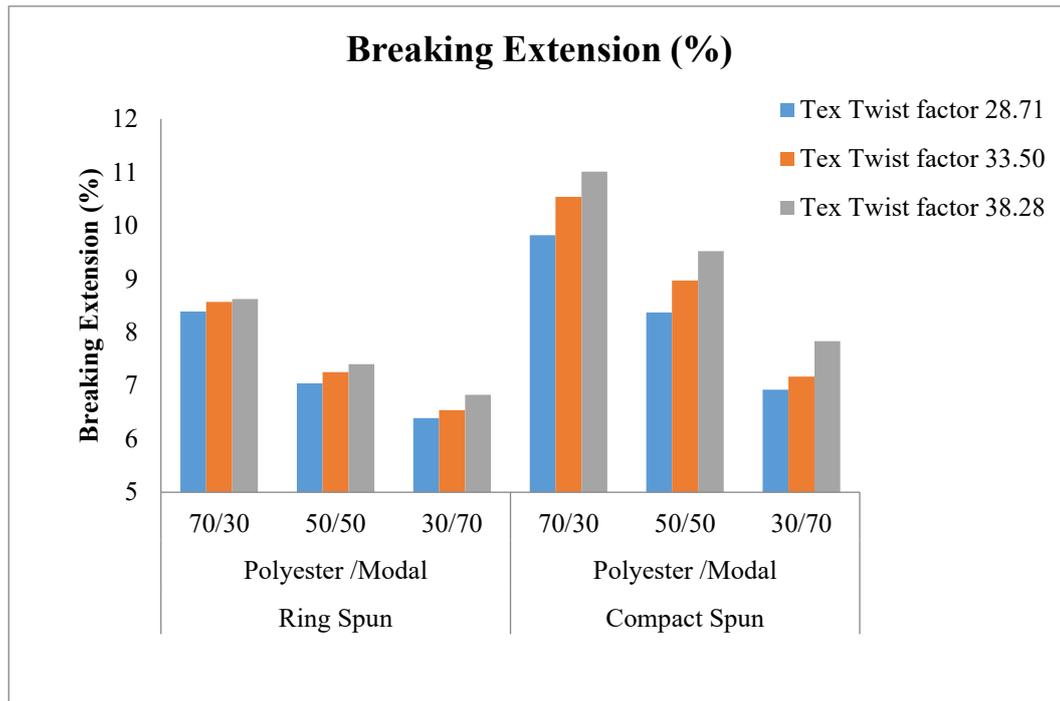


Figure:-2- Influence of Fibre Composition and Tex Twist Factor on Breaking Extension (%) of Polyester/Modal Blended Ring and Compact Spun Yarns

Mass irregularity (U%)

Mass irregularity (U%) is representing the variation in mass per unit length of yarn and directly reflects drafting performance, fibre cohesion, and structural uniformity. The results clearly indicate that both fibre composition and tex twist factor significantly influence mass irregularity, with distinct differences observed between ring and compact spinning systems.

In the case of ring-spun yarns, mass irregularity increased progressively with increasing modal content at all twist factors. At a tex twist factor of 28.71, the U% values were 12.59% for the 70/30 blend, 14.29% for the 50/50 blend, and 15.98% for the 30/70 blend. A similar trend persisted at higher twist factors, where the 30/70 blend consistently exhibited the highest irregularity, reaching 16.87% at a twist factor of 38.28. This increase in unevenness with higher modal proportion can be attributed to the lower stiffness and higher flexibility of modal fibres, which tend to cause drafting instabilities and floating fibres during spinning. Polyester fibres, owing to their higher strength and resilience, provide better control during drafting and contribute to improved mass uniformity. Thus, increasing polyester content enhances yarn regularity.

The influence of twist factor on ring-spun yarns showed a slight but consistent increase in U% with higher twist levels. In the 70/30 blend, U% increased from 12.59% at 28.71 twist factor to 13.20% at 38.28. This trend may be associated as the twist factor increases; the drafting speed decreases because higher twist is achieved by reducing the front roller delivery rate. A lower drafting speed reduces the dynamic friction between fibres, which influences fibre movement within the drafting zone. However, the reduction in drafting speed leads to lesser control over fibre movement due to decreased dynamic friction. Consequently, yarn evenness deteriorates with an increase in twist factor.

Compact-spun yarns exhibited significantly lower mass irregularity compared to ring-spun yarns across all blend ratios and twist factors. At a twist factor of 28.71, U% values for compact yarns were 11.47% (70/30), 12.04% (50/50), and 12.62% (30/70), which are markedly lower than corresponding ring yarn values. Even at the highest twist factor (38.28), compact yarn irregularity remained relatively stable, with values of 11.76%, 12.39%, and 12.84% for 70/30, 50/50, and 30/70 blends, respectively. The superior uniformity of compact yarns can be attributed to the elimination of the spinning triangle and improved fibre condensation, which enhance fibre alignment and reduce drafting wave effects. The compacting zone ensures better control of edge fibres, thereby minimizing mass variation along the yarn length.

Table:-3 - Influence of Fibre Composition and Tex Twist Factor on Mass Irregularity (U%) of Polyester/Modal Blended Ring and Compact Spun 19.6 Tex Yarns

Tex Twist Factor	Ring Spun			Compact Spun		
	Blend Ratio (Polyester /Modal)			Blend Ratio (Polyester /Modal)		
	70/30	50/50	30/70	70/30	50/50	30/70
28.71	12.59	14.29	15.98	11.47	12.04	12.62
33.50	12.97	14.56	16.14	11.69	12.25	12.76
38.28	13.20	15.04	16.87	11.76	12.39	12.84

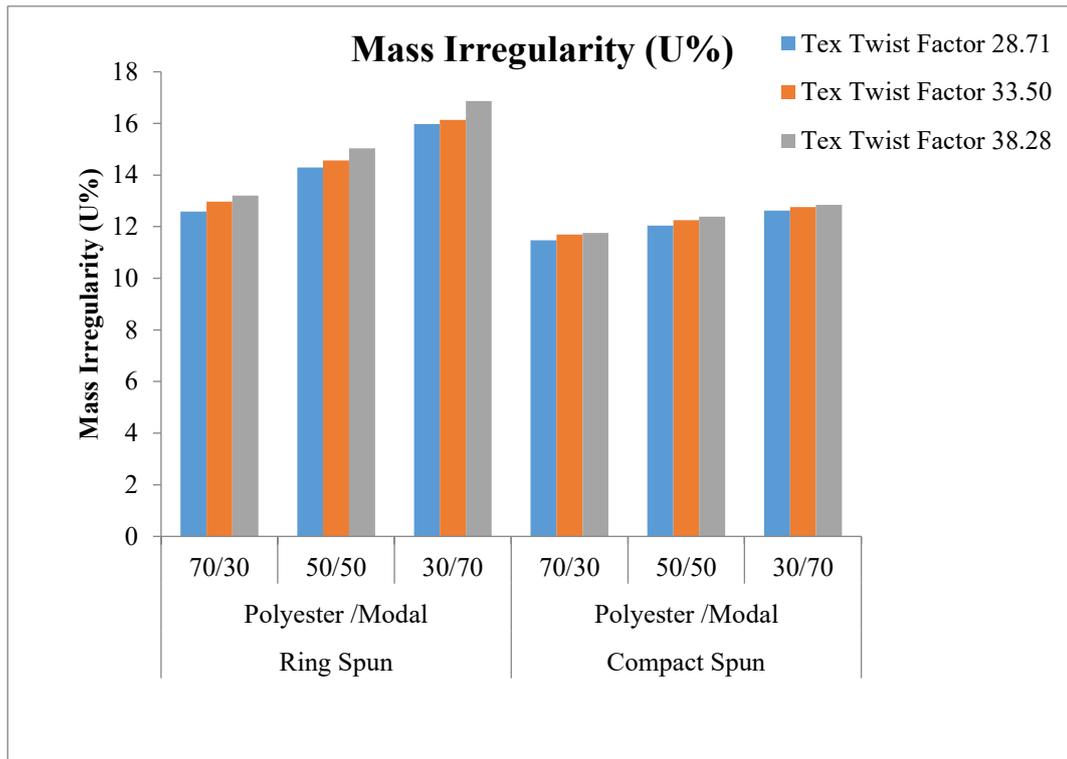


Figure:-3- Influence of Fibre Composition and Tex Twist Factor on Mass Irregularity (U%) of Polyester/Modal Blended Ring and Compact Spun 19.6 Tex Yarns

Imperfections

Yarn imperfections per kilometer (thin places, thick places, and neps) are critical indicators of yarn quality and processing performance. The experimental results reveal that both fibre composition and tex twist factor significantly affect the number of imperfections, with substantial differences between ring and compact spinning systems.

For ring-spun yarns, imperfections/km increased markedly with increasing modal content across all twist factors. At a twist factor of 28.71, the 70/30 blend recorded 209 imperfections/km, while the 50/50 and 30/70 blends exhibited much higher values of 671 and 780 imperfections/km, respectively. This trend persisted at higher twist levels, with the 30/70 blend reaching 887 imperfections/km at a twist factor of 38.28. The higher imperfection levels in modal-rich blends can be attributed to the lower breaking extension and lower stiffness of modal fibres, which tend to cause drafting irregularities, fibre clustering, and poor fibre control during spinning. Polyester fibres, having higher strength and resilience, improve fibre cohesion and reduce the formation of thin and thick places, thereby lowering imperfection counts.

The influence of twist factor on ring-spun yarns shows a consistent increase in imperfections with increasing twist. In case of 70/30 blend, imperfections rose from 209 at 28.71 twist factor to 307 at 38.28. This increase may be due to lesser control on fibre movement because of reduced drafting speed as well as enhanced torsional stress and fibre migration at higher twist levels, which can exaggerate minor structural variations and convert them into measurable faults. Moreover, excessive twist can increase yarn rigidity, making localized mass variations more pronounced during evenness testing.

Compact-spun yarns demonstrated significantly lower imperfections/km compared to ring-spun yarns for all blend ratios and twist factors. At 28.71 twist factor, compact yarns showed only 93 imperfections/km for the 70/30 blend, compared to 209 in ring yarns. Similarly, for the 30/70 blend, compact yarns recorded 170 imperfections/km versus 780 in ring yarns. Even at the highest twist factor (38.28), compact yarn imperfections remained considerably lower (129, 161, and 243 for 70/30, 50/50, and 30/70 blends, respectively). This substantial reduction can be attributed to the aerodynamic compacting system, which eliminates the spinning triangle and enhances fibre alignment and packing density. Improved fibre condensation reduces edge fibre loss, minimizes drafting wave's effect, and significantly decreases the occurrence of thin and thick places.

Although imperfections in compact yarns increased slightly with increasing twist factor, the magnitude of increase was much lower compared to ring yarns. This indicates that compact spinning provides better structural stability even under higher twist conditions.

Table:-4 - Influence of Fibre Composition and Tex Twist Factor on Imperfections/km of Polyester/Modal Blended Ring and Compact Spun 19.6 Tex Yarns

Tex Twist Factor	Ring Spun			Compact Spun		
	Polyester /Modal			Polyester /Modal		
	70/30	50/50	30/70	70/30	50/50	30/70
28.71	209	671	780	93	127	170
33.50	253	700	849	101	143	196

38.28	307	732	887	129	161	243
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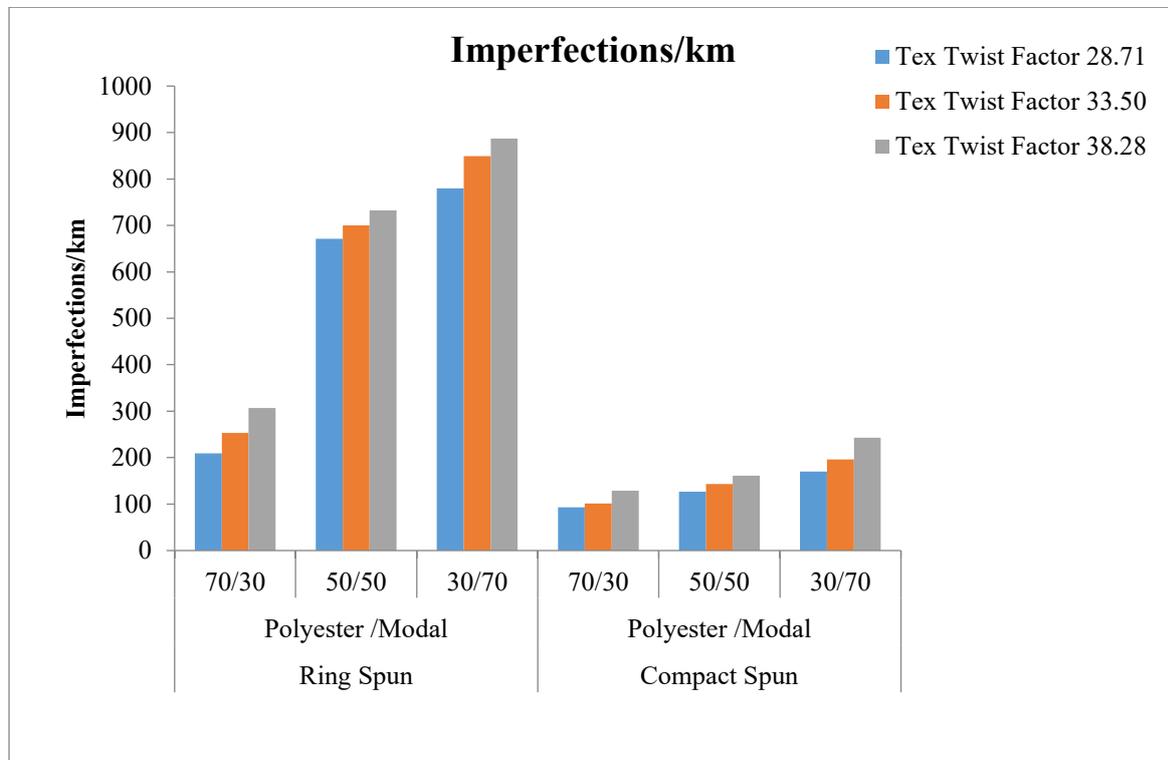


Figure:-4- Influence of Fibre Composition and Tex Twist Factor on Imperfections/km of Polyester/Modal Blended Ring and Compact Spun 19.6 Tex Yarns

Hairiness

Hairiness (S_3) is a critical parameter influencing fabric appearance, pilling tendency, and processing performance. The results clearly demonstrate that fibre composition, tex twist factor, and spinning system significantly affect yarn hairiness.

For ring-spun yarns, hairiness values decreased consistently with increasing twist factor across all blend ratios. At a twist factor of 28.71, hairiness values were 17, 23, and 33 for 70/30, 50/50, and 30/70 blends, respectively. As the twist factor increased to 38.28, hairiness reduced to 11, 14, and 19, respectively. This reduction is attributed to improved fibre binding and tighter yarn structure at higher twist levels, which effectively restrains surface fibres and reduces fibre protrusion. Increased twist enhances radial pressure within the yarn, pulling loose fibres into the yarn body and thereby minimizing hairiness.

Fibre composition had a pronounced effect on hairiness. Yarns with higher modal content exhibited significantly greater hairiness at all twist levels. The 30/70 blend consistently recorded the highest S_3 values, while the 70/30 blend showed the lowest. This behaviour may be explained by the lower stiffness and higher flexibility of modal fibres, which tend to protrude more easily from the yarn surface during spinning. In contrast, polyester fibres possess higher resilience and better recovery characteristics, allowing them to remain more effectively integrated within the yarn structure, thus reducing hairiness.

Compact-spun yarns exhibited substantially lower hairiness compared to ring-spun yarns for all blend ratios and twist factors. At a twist factor of 28.71, compact yarn hairiness values were 12, 18, and 23 for 70/30, 50/50, and 30/70 blends, respectively—considerably lower than corresponding ring yarn values. At the highest twist factor (38.28), hairiness further decreased to 8, 11, and 14. The significant reduction in hairiness in compact yarns can be attributed to the elimination of the spinning triangle and improved fibre condensation in the compacting zone [10, 11]. The aerodynamic compacting system ensures better control of edge fibres, leading to enhanced fibre alignment and tighter yarn packing, thereby minimizing fibre protrusion.

Table:-5 - Influence of Fibre Composition and Tex Twist Factor on Hairiness (S_3) of Polyester/Modal Blended Ring and Compact Spun 19.6 Tex Yarns

Tex Twist Factor	Ring Spun			Compact Spun		
	Polyester /Modal			Polyester /Modal		
	70/30	50/50	30/70	70/30	50/50	30/70
28.71	17	23	33	12	18	23
33.50	13	19	25	11	15	21
38.28	11	14	19	8	11	14

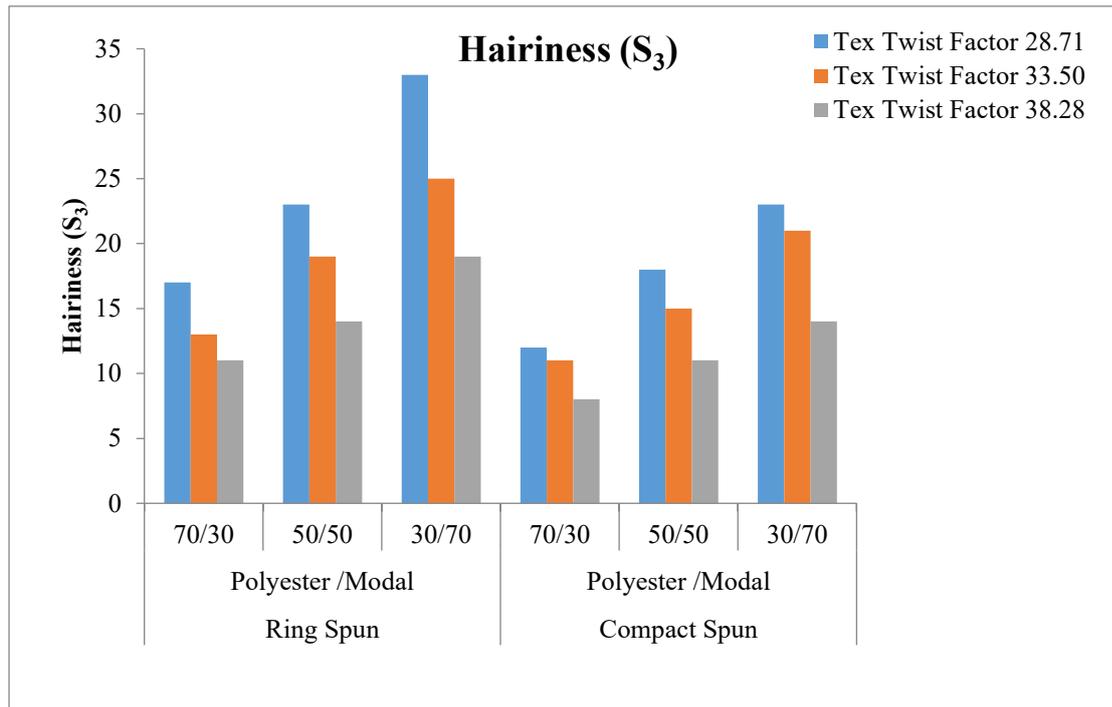


Figure:-5- Influence of Fibre Composition and Tex Twist Factor on Hairiness (S_3) of Polyester/Modal Blended Ring and Compact Spun 19.6 Tex Yarns

Yarn diameter

Yarn diameter is an important structural parameter that reflects fibre packing density, twist consolidation, and overall compactness of the yarn body. The experimental results indicate that both fibre composition and tex twist factor significantly influence yarn diameter, with clear differences observed between ring and compact spinning systems.

For ring-spun yarns, yarn diameter decreased progressively with increasing twist factor across all blend ratios. For the 70/30 polyester/modal blend, diameter reduced from 0.2094 mm at a twist factor of 28.71 to 0.1995 mm at 38.28. Similar decreasing trends were observed for the 50/50 blend (0.2042 mm to 0.1978 mm) and the 30/70 blend (0.1989 mm to 0.1927 mm). This reduction in diameter with increasing twist is attributed to enhanced fibre consolidation and increased radial pressure within the yarn structure. As twist increases, fibres are drawn closer to the yarn axis, resulting in tighter packing and a more compact cross-section.

Fibre composition also had a noticeable effect on yarn diameter. At all twist levels, yarn diameter decreased with increasing modal content. For instance, at a twist factor of 28.71, the 70/30 blend exhibited the largest diameter (0.2094 mm), while the 30/70 blend showed the smallest (0.1989

mm). This trend may be explained by higher elongation and resilience of polyester, may occupy slightly more radial space when twisted, leading to marginally larger diameters in polyester-rich blends.

Compact-spun yarns consistently exhibited significantly smaller diameters compared to ring-spun yarns at all blend ratios and twist factors. At 28.71 twist factor, compact yarn diameters ranged from 0.1747 mm (70/30) to 0.1689 mm (30/70), substantially lower than corresponding ring yarn values. The same pattern persisted at higher twist factors, with the smallest diameter (0.1591 mm) observed for the 30/70 blend at 38.28 twist factor. The reduced diameter in compact yarns is attributed to the reduction in the size of the spinning triangle and improved fibre condensation in the aerodynamic compacting zone. This process enhances fibre alignment and significantly increases packing density, resulting in a more circular and compact yarn cross-section. As twist increases, both systems exhibit further reduction in diameter, but the relative change is smaller in compact yarns due to their initially higher compactness.

Table:-6 - Influence of Fibre Composition and Tex Twist Factor on Yarn Diameter (mm) of Polyester/Modal Blended Ring and Compact Spun 19.6 Tex Yarns

Tex Twist Factor	Ring Spun			Compact Spun		
	Polyester /Modal			Polyester /Modal		
	70/30	50/50	30/70	70/30	50/50	30/70
28.71	0.2094	0.2042	0.1989	0.1747	0.1708	0.1689
33.50	0.2057	0.2013	0.1976	0.1701	0.1678	0.1646
38.28	0.1995	0.1978	0.1927	0.1689	0.1656	0.1591

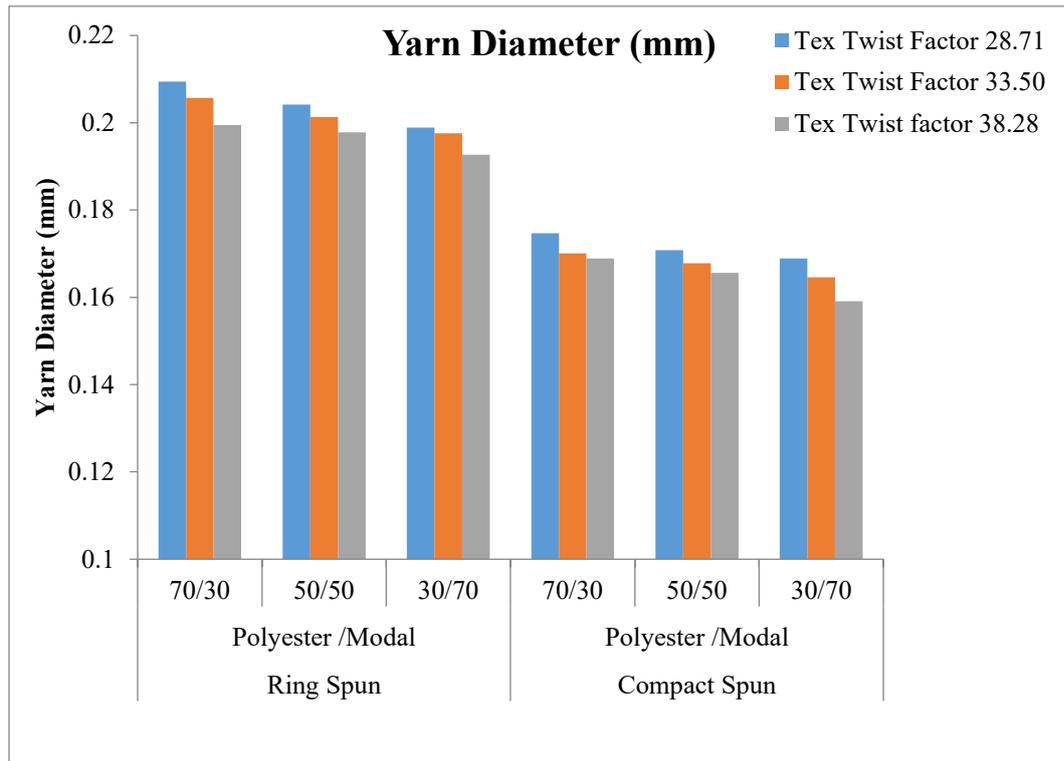


Figure:-6- Influence of Fibre Composition and Tex Twist Factor on Yarn Diameter (mm) of Polyester/Modal Blended Ring and Compact Spun 19.6 Tex Yarns

Yarn Shrinkage

Yarn shrinkage (%) reflects the relaxation behaviour of fibres and the release of internal stresses generated during spinning. The results indicate that yarn shrinkage is significantly influenced by fibre composition, tex twist factor, and spinning system, with clear structural differences observed between ring and compact-spun yarns.

For ring-spun yarns, shrinkage increased consistently with increasing twist factor across all blend ratios. In the 70/30 polyester/modal blend, shrinkage rose from 1.47% at a twist factor of 28.71 to 2.13% at 38.28. Similar increasing trends were observed for the 50/50 blend (1.25% to 1.89%) and the 30/70 blend (0.98% to 1.64%). The increase in shrinkage with higher twist can be attributed to the greater torsional strain and internal stress introduced during yarn formation. Higher twist levels generate increased fibre angularity and stored elastic energy within the yarn structure, which is subsequently released during relaxation, resulting in higher shrinkage.

Fibre composition also had a pronounced effect on shrinkage behaviour. Yarns with higher polyester content exhibited greater shrinkage compared to modal-rich blends. At all twist levels, the 70/30 blend showed the highest shrinkage values, while the 30/70 blend recorded the lowest. This behaviour can be explained by the higher breaking extension and elastic recovery characteristics of polyester fibres, which contribute to greater stress accumulation during twisting and increased relaxation shrinkage. In contrast, modal fibres, having lower elongation and less elastic recovery, exhibit reduced internal stress development, leading to lower shrinkage percentages.

Compact-spun yarns consistently demonstrated significantly lower shrinkage compared to ring-spun yarns for all blend ratios and twist factors. For example, at a twist factor of 28.71, shrinkage in compact yarns ranged from 0.41% (30/70 blend) to 0.89% (70/30 blend), substantially lower than the corresponding ring yarn values. Even at the highest twist factor (38.28), compact yarn shrinkage remained lower (1.17%, 1.02%, and 0.81% for 70/30, 50/50, and 30/70 blends, respectively) than that of ring yarns. The reduced shrinkage in compact yarns can be attributed to improved fibre alignment, higher packing density. These structural advantages minimize uneven fibre migration and reduce residual torsional stress within the yarn body, thereby limiting relaxation shrinkage.

Although shrinkage increased with twist factor in both spinning systems, the rate of increase was more pronounced in ring-spun yarns, indicating higher stress accumulation during conventional spinning. Compact spinning, due to its enhanced fibre control and structural consolidation, produces yarns with better dimensional stability.

Table:-7 - Influence of Fibre Composition and Tex Twist Factor on Yarn Shrinkage (%) of Polyester/Modal Blended Ring and Compact Spun 19.6 Tex Yarns

Tex Twist Factor	Ring Spun			Compact Spun		
	Polyester /Modal			Polyester /Modal		
	70/30	50/50	30/70	70/30	50/50	30/70

28.71	1.47	1.25	0.98	0.89	0.67	0.41
33.50	1.94	1.70	1.45	1.05	0.83	0.67
38.28	2.13	1.89	1.64	1.17	1.02	0.81

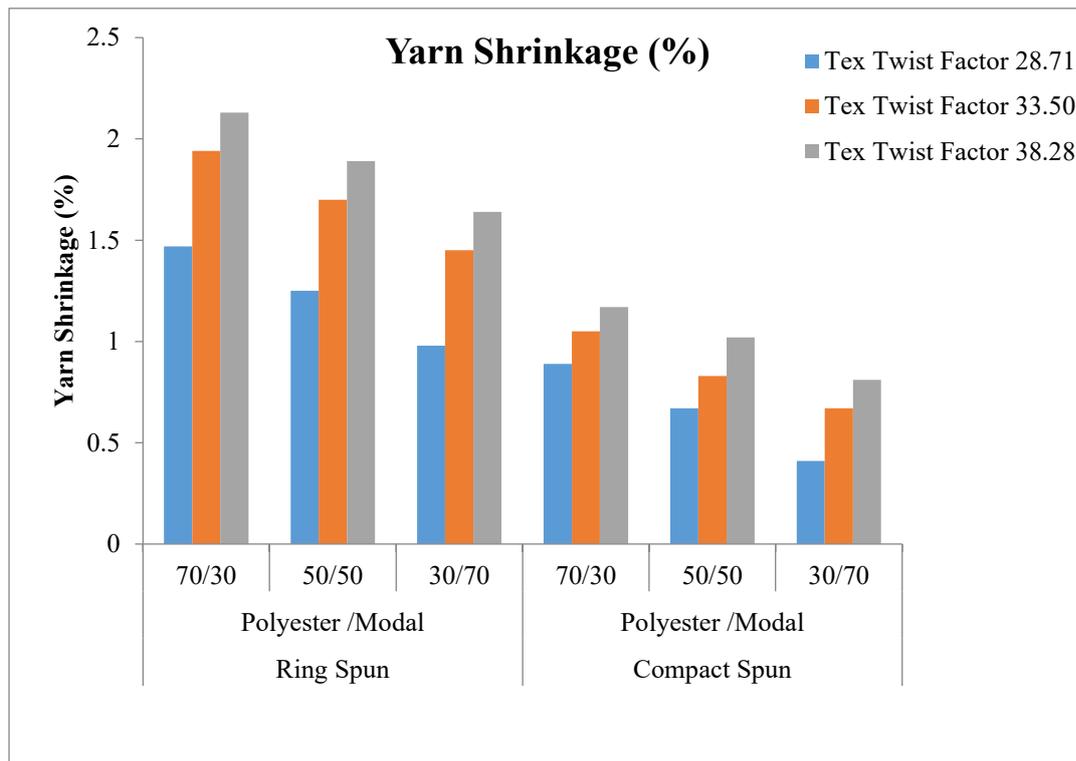


Figure:-7- Influence of Fibre Composition and Tex Twist Factor on Yarn Shrinkage (%) of Polyester/Modal Blended Ring and Compact Spun 19.6 Tex Yarns

CONCLUSION

The present study systematically evaluated the mechanical and physical properties of polyester/modal blended yarns produced through conventional ring and compact spinning systems at varying blend ratios and tex twist factors. The results clearly demonstrate that fibre composition, twist factor, and spinning technology collectively and significantly influence yarn performance.

Tenacity results confirmed that yarn strength increased with twist factor up to an optimum level (33.50), beyond which it declined due to increased fibre obliquity and reduced axial stress contribution. Polyester-rich blends (70/30) consistently exhibited superior tensile strength compared to modal-rich blends, reflecting the higher intrinsic tenacity and elongation of polyester

fibres. Compact-spun yarns showed markedly higher strength than ring-spun yarns across all blend ratios and twist levels, owing to improved fibre alignment, elimination of the spinning triangle, and enhanced packing density.

Breaking extension was positively influenced by increasing polyester content and twist factor. Compact yarns demonstrated superior extensibility compared to ring yarns, indicating more efficient stress distribution and improved fibre participation during tensile loading. Within the studied twist range, compact spinning effectively enhanced elongation without compromising structural integrity.

Mass irregularity and imperfections were strongly affected by fibre composition. Modal-rich blends exhibited higher U% and imperfection counts, attributed to the comparatively lower stiffness and drafting stability of modal fibres. Increasing twist factor slightly increased unevenness and imperfections in ring-spun yarns due to amplified structural tightening and torsional stresses. However, compact-spun yarns consistently demonstrated significantly lower mass irregularity and fewer imperfections, confirming the effectiveness of aerodynamic fibre condensation in improving yarn uniformity.

Hairiness decreased with increasing twist factor for both spinning systems, as higher twist improved fibre binding and reduced fibre protrusion. Polyester-rich blends exhibited lower hairiness compared to modal-rich blends. Compact spinning substantially reduced hairiness at all twist levels due to better edge fibre control and elimination of the spinning triangle.

Yarn diameter decreased progressively with increasing twist factor, reflecting enhanced fibre consolidation and increased packing density. Compact-spun yarns consistently showed smaller diameters than ring-spun yarns, indicating superior structural compactness. Similarly, yarn shrinkage increased with higher twist levels and higher polyester content due to increased torsional stress and elastic recovery. However, compact yarns exhibited significantly lower shrinkage compared to ring yarns, demonstrating improved dimensional stability resulting from better fibre alignment and reduced residual stress.

Overall, the findings confirm that compact spinning significantly enhances yarn mechanical performance, uniformity, surface characteristics, and dimensional stability compared to conventional ring spinning. Polyester-rich blends (70/30) at an optimum twist factor of 33.50

produced the most balanced performance in terms of strength, extensibility, uniformity, and structural compactness.

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