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Evaluation of Mechanical and Physical Characteristics of Eco blended Melange Yarns

Vrednotenje mehanskih in fizikalnih lastnosti ekomelanžne preje

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Abstract
The production and consumption of melange yarns are gradually increasing due to natural multi-colours and strong 3D fashionable effects. The raw material and chemical processing influence the environmental and textile values of the melange yarn. Organic cotton and regenerated cellulose fibres are basic raw materials for eco-friendly production of yarns. In this study three different regenerated fibres are blended with organic cotton in three different ratios to manufacture the blended melange yarns of two different shade depths. Therefore, cotton-bamboo viscose, cotton-lyocell and cotton-SeaCell™ blended melange yarns with three blend combination 30/70, 50/50 and 70/30 are manufactured. All the dyed and grey components are mixed at the blow room. The aim of the study is to investigate impact of raw material and blend ratio on mechanical and physical characteristics of different shade depth blended melange yarns. Better yarn characteristics with respect to yarn evenness, imperfections, hairiness, tenacity, elongation, coefficient of friction and diameter are achieved for lower shade depth melange yarn. In cotton-rich blended melange yarns, elongation, hairiness, evenness, total imperfections and diameter are noticeably worse for all the combinations. Statistical analysis shows significant effect of blend type, blend ratio and shade depth on the all yarn properties.
Keywords: bamboo viscose, *Tencel*^{TM}, *SeaCell*^{TM}, shade depth, melange spinning

Izvleček
Proizvodnja in poraba melanžne preje se postopoma povečuje zaradi naravne večbarvnosti in zelo modnih 3D estetskih učinkov. Surovine in kemična obdelava vplivajo na okolje in tekstilne lastnosti melanžne preje. Organski bombaž in regenerirana celulozna vlakna so osnovne surovine za okolju prijazno proizvodnjo preje. Z namenom, da bi dosegli različne barvne nianse, so bile v študiji izdelane melanžne preje iz mešanic vlaken bombaž/bambusova viskoza, bombaž/liocel in bombaž/SeaCell^{TM}*, v razmerjih 30/70, 50/50 in 70/30. Barvane in surove komponente vlaken so bile mešane v fazah priprave prediva. Namen študije je bil raziskati vpliv razmerja surovin v mešanicah na mehanske in fizikalne lastnosti melanžnih prej. Boljše lastnosti prej glede enakomernosti, količine napak, kosmatosti, trdnosti, raztezka, koeficienta trenja in premera so bile dosežene pri melanžnih prejah s svetlejšim barvnim tonom. V melanžnih prejah z večjim deležem bombaža so bile pri vseh mešanicah ugotovljene slabše vrednosti raztezka, kosmatosti, enakomernosti, količine napak in premera. Statistična analiza je pokazala pomemben vpliv vrste mešanice, razmerja mešanice in globine barvnega tona na vse lastnosti preje.*
Ključne besede: bambusova viskoza,Tencel^{TM}*, SeaCell*^{TM}*, barvne nianse, izdelava melanžne preje*

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1 Introduction

The increase in global demand for clothing is expected to continue, not only due to an increase in the world's population, but also due to living standards, economic activities and developments. In the present era, clothing serves many purposes. It not only satisfies the basic needs of human beings, but is also used as a symbol to express wealth, status, occupation, leisure and eco-friendliness [1]. Fibre is one of the basic units for producing desirable clothes [2]. Biodegradable and sustainable fibres are being developed for environmental protection and providing a significant opportunity for sustainable textiles [3].
Cotton is considered the most eco-friendly, but the use of insecticides and pesticides in cultivation make it less sustainable. Organic cotton and regenerated cellulose fibres may serve as a substitute for polluted cotton [4]. Regenerated cellulose fibres, such as viscose rayon, bamboo rayon, modal rayon, lyocell and SeaCell™ are widely considered the most important for environmental aspects and often referred to as environmentally friendly [5]. Bamboo rayon is produced by wet spinning, while lyocell and SeaCell™ fibres are produced by solvent spinning. Bamboo rayon is naturally antibacterial, breathable, green, biodegradable, soft, flexible and strong, with a luxurious, shiny appearance [6]. Modal is a second generation regenerated cellulose fibre and is known for its softness [5]. Lyocell is a third-generation fibre. It is highly absorbent, soft, has a high wet or dry strength, and is wrinkle resistant [7]. SeaCell™ and smartcell are modified versions of third generation fibre. Their advantages include the environmental friendliness of processing, combined with their softness, drape and antibacterial properties [8-10].
In the production of SeaCell™ fibre, powdered seaweeds are firmly incorporated into a natural cellulose fibre. As a result, the positive properties of the seaweed are permanently preserved within the fibre, even after multiple washes [10, 11].
All regenerated cellulosic fibres have the same basic unit, but are quite different in degree of polymerisation, molecular arrangement, molecular mass, degree of orientation and crystallinity [12]. The lyocell and SeaCell™ have a circular cross section and a smooth longitudinal surface. On the other hand, bamboo rayon and viscose rayon possess an irregular and toothed cross section, micro-gaps and micro-holes with striated cracks distributed over the longitudinal surface [13, 14].

A single fibre yarn cannot offer all the desired characteristics. The blending of different types of fibres not only enhances the functional or mechanical performance, but also the aesthetic qualities of textile fabric. Blending is also practiced in industry for cost minimisation [15, 16]. Many researchers have investigated blended yarn properties and analysed their functional and mechanical attributes. Sowmya et al. [15] reported that yarn unevenness is affected by the blended ratio of cotton, polyester, and regenerated bamboo fibre. They also reported that the work of rupture and elongation at break of bamboo-cotton blended yarns are found to be lower than those of bamboo/polyester-blended yarns. Tyagi et al. [16] reported that Tencel™-polyester yarns yield more satisfactory results than Tencel™-cotton yarns in terms of tenacity, breaking elongation, mass regularity, imperfections and work of rupture for all spinning system. Increasing the Tencel™ content both in Tencel™-polyester and Tencel™-cotton fibre blends makes the yarn rigid and hairier. Kilic et al. [17] determined that yarn-to-yarn friction decreases, while yarn-to-metal and yarn-to-ceramic friction increases when the ratio of Tencel™ in Tencel™-cotton blended yarn is increased. Majumdar et al. [6] reported that yarn diameter reduces as the proportion of bamboo fibre is increased in the blend of bamboo cotton fibre. Kılıç and Okur [14] found that unevenness, imperfections, diameter and roughness values decrease when the regenerated cellulosic fibre content in cotton-Tencel™ and cotton-paramodal blended yarns is increased, while increasing breaking force, elongation, density and shape values. Avik et al. [11] worked on the functional properties of SeaCell™ sock and summarise that SeaCell™ socks may be a good choice for people with foot problems such as fungus. SeaCell™ fibre has a more homogenous pore distribution, which in turn facilitates improved water transport.
All of the above research was performed on the manufacturing of plain blended yarn. But there is another field where the blending/mixing of different colours or the dye affinities of fibres are performed for the production of fancy or melange yarns [18–19]. Melange yarns are fancy yarns consisting of a wavy effect, a wide range of colour tones and unique colour effects. They are manufactured to achieve higher rates due to the aesthetics and obsolescence of fashion [20]. Researchers reported that cotton fibres suffer from a decrease in strength

and change in surface properties after being dyed due to the aggressive nature of chemicals and the removal of a large portion of the wax present on the surface of cotton fibres [21, 22]. The dyeing of fibres results in their greater entanglement and cohesion. The average length of dyed fibre decreases with a higher rate than that of undyed fibre after going through opening and mechanical processes. Various stages of spinning cause tip fibrillation, end rupture, transverse cracks, deep cracks, a saw-tooth effect and rippling damage. Dyed fibres are more prone to damage than undyed fibres [22, 23]. Fibre damage not only affects the efficiency of the spinning process, but also the mechanical properties of the final yarn and fabric. The quality of cotton melange yarn is affected significantly by the applied blending method [24, 25].

Conventional approaches used in the manufacturing of melange yarn are entirely dependent on cotton fibre in the melange yarn industry. None of the researchers mentioned above have focused on the properties of eco-friendly blended melange yarns. In this study, two different shade depth cotton blended melange yarns were produced using bamboo viscose, lyocell and SeaCell™ fibres in three different proportions that might be useful for the textile melange yarn industry in terms of exploring new applications for melange products.

2 Materials and methods

2.1 Materials for melange yarn production

Dyed and grey H-4 organic combed cotton, bamboo viscose, lyocell and SeaCell™ fibres were used to produce 19.68 tex (30s Ne) melange yarns. The properties of the fibres that were used to produce the yarns are summarised in Tables 1a and 1b.

The results presented in Tables 1a and 1b show that dyeing and opening have an adverse effect on the tensile and length properties of fibres. It was also observed that cotton fibres show incremental changes in short fibre content and neps/g after dyeing and opening.

2.2 Melange yarn production

The mixing or blending of dyed and un-dyed (grey) fibres in predefined ratios results in melange yarns. Shade depth (%) is a common term used in melange yarn spinning to illustrate the percentage contribution of dyed fibre in a blend. In this study, the blending of fibres (dyed/un-dyed, cotton or regenerated cellulose) was performed in a blow room to achieve the perfect regularity of colour and structure. Figure 1 depicts the process flow of melange yarn spinning. Grey fibres for dyeing or mixing are prepared in the first stage. A predefined amount of grey fibres is dyed in the second stage, while the third stage involves the stack blending of grey and dyed fibres in the required ratio in the blow room. Cotton fibres

Table 1a: Properties of combed grey and dyed cotton fibres

Fibre quality	Instruments					
	HVI (HVI mode)				AFIS	
	Fineness (mic.)	Length (mm)	Strength (g/tex)	Elongation (%)	Short fibre content (%)	Fibre neps (neps/g)
Grey combed	4.23	29.3	29.37	6.14	18.02	14
Dyed combed	4.2	29.0	28.12	5.9	19.32	18
Dyed combed (after opening)	4.2	28.7	27.24	5.97	21.57	24

Table 1b: Properties of grey and dyed regenerated cellulose fibres

Type of fibre	Bamboo viscose (BV)		Lyocell (L)		SeaCell™ (S)	
	Grey	Dyed	Grey	Dyed	Grey	Dyed
Fineness (dtex)	1.56	1.56	1.56	1.56	1.67	1.67
Length (mm)	37.90 (38)	37.65 (38)	37.92 (38)	37.81(38)	37.9(38)	37.7(38)
Strength (g/tex)	23.2	21.0	36.23	35.0	29.00	28.1
Elongation (%)	11.8	11.5	9.7	9.5	11.2	10.9

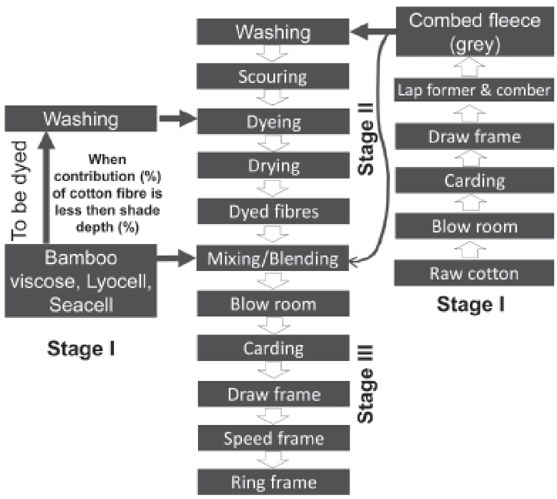

Figure 1: Process flow of melange yarn manufacturing

are preferred over the regenerated cellulose fibres for dyeing to achieve the proper shade depth (%).

2.3 Design of experiment

Light and dark melange yarns were produced on a short staple spinning machine by blending three different fibres and blend compositions with cotton. All the process variables were kept constant. The aim of varying the factors was to investigate the interaction effect of fibre properties and composition with different shade depths. The design plan of the experiment is presented in Table 2. A total of 18 yarn samples were manufactured according to full factorial design.

2.4 Methods

The yarn samples were conditioned at a standard tropical atmospheric condition of 65 ± 2% RH and 27 ± 2 °C temperatures for 24 hours.

2.4.1 Tensile testing of yarn

An Instron universal testing machine was used to measure the breaking load and extension properties. The yarn samples were tested at 120 mm/min extension rate using a gauge length of 500 mm (ASTM D 2256). A total of 50 readings were taken for each sample.

2.4.2 Unevenness, thin, thick, neps and hairiness

The unevenness, thin, thick, neps and hairiness were measured using an Uster Evenness Tester-5. Thin places (-50%), thick places (+50%) and neps (+200%) were considered to measure total imperfection in the melange yarn.

2.4.3 Yarn diameter

The diameter of yarn was measured by an optical method using a Leica image analyser. At least 100 readings were taken for each sample.

2.4.4 Coefficient of friction

An Uster Zweigle Friction Tester 5 was used to measure fibre to metal friction. The friction coefficient (μ) was calculated using the formula $F_2 = \mu F_1$, where F_1 is constant force applied to produce a defined force on the yarn in a vertical direction and F_2 is the force required to pull the yarn.

3 Results and discussion

This paper includes an analysis of cotton blended melange yarn with varying parameters. In this study, parameters were assessed in terms of unevenness, total imperfections, hairiness, tenacity, elongation, yarn diameter and coefficient of friction of the melange yarns. An analysis of variance was carried out to determine the effect of different parameters on yarn properties. The ANOVA of the parameters is presented in Table 3.

It is evident from Table 3 that the blend ratio has a significant impact on all the properties of the yarn, while blend type has a significant effect on all properties except unevenness.

Table 2: Experiment design plan

Sr. No.	Factors	Levels		
1	Blend type	Cotton/Bamboo viscose (C/BV)	Cotton/Lyocell (C/L)	Cotton/SeaCell™ (C/S)
2	Blend ratio	30/70	50/50	70/30
3	Shade depth (%)	20 (light); 70 (dark)	20 (light); 70 (dark)	20 (light); 70 (dark)

Table 3: ANOVA results for yarn characteristics

Factors	Unevenness	IPI	Hairiness	Tenacity	Breaking Extension	Diameter	Coefficient of friction
BT	NS (0.19)	S (0.000)	S (0.0009)	S (0.000)	S (0.000)	S (0.014)	S (0.001)
BR	S (0.0003)	S (0.000)	S (0.0001)	S (0.0001)	S (0.0000)	S (0.034))	S (0.0000)
SD	S (0.0001)	S (0.000)	S (0.001)	S (0.029)	S (0.0004)	NS (0.450)	S (0.006)
BT×BR	NS (0.5757)	NS (0.172)	NS (0.163)	S (0.0004)	S (0.0001)	NS (0.283)	NS (0.216)
BT×SD	NS (0.2813)	S (0.0001)	NS (0.792)	S (0.002)	S (0.013)	NS (0.146)	NS (0.444)
BR×SD	S (0.0226)	S (0.045)	NS (0.664)	S (0.027)	NS (0.18)	NS (0.683)	NS (0.500)

BT – blend type, BR – blend ratio, SD – shade depth. Values in parenthesis are p-values, calculated at 95% statistical probability: $p \leq 0.05$ – result is statistically significant (S), $p > 0.05$ – result is not statistically significant (NS)

3.1 Tensile characteristics of melange yarn

The tensile attributes of a staple fibre melange yarn are influenced by fibre characteristics. Tenacity and breaking extension are important properties for assessing the tensile behaviour of melange yarn. Blend type, blend ratio and shade depth have a significant impact on the tenacity and breaking extension of blended melange yarn (Table 3). Tenacity is the applied load with respect to fineness at which a specimen breaks. The effect of blend type and blend ratio on tenacity for different shade depth blended melange yarns is presented in Figure 2.

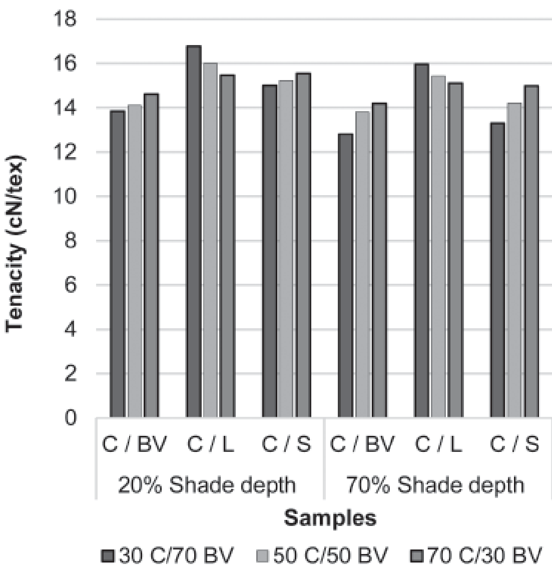

Figure 2: Effect of blend type and blend ratio on tenacity

It is evident from Figure 2 that:

– cotton-lyocell blended yarn shows the highest tenacity, followed by cotton-SeaCell™ and cotton-bamboo viscose blended yarns for both shade depths;
– melange yarn tenacity increases with an increase in the cotton component in the case of bamboo viscose and SeaCell™-blended yarns, and decreases in lyocell-blended yarn; and
– tenacity of melange yarn decreases with an increase in shade depth.

Lyocell fibres have a high degree of polymerisation compared to bamboo viscose and SeaCell™ fibres due to their long molecular chains [13], so that the strength of the yarns produced from lyocell fibre showed a higher tenacity, followed by cotton-SeaCell™ and cotton-bamboo viscose blended yarn for both shade depths.

The bamboo viscose fibre has a lower strength and higher amorphous region in the macromolecular structure than cotton fibre. Blended yarn with rich bamboo viscose fibre demonstrates a lower tenacity. SeaCell™ fibre possesses much higher elongation than cotton fibre. During the loading of cotton-SeaCell™ blended yarn, cotton fibres will resist further elongation and are expected to reach the breaking point earlier. The difference is marginal.

Dyed fibres are weaker than undyed fibre (Table 1), while 70% shade depth melange yarn consists of more dyed fibre. Simultaneously dyeing causes entanglement, causes difficulties during opening and drafting, and ultimately leads to rupture. For these reasons, the load bearing capacity of survival fibres decreases and stress increases during tensile testing, causing a rupture to propagate faster across the cross section in high shade depth yarn.

The effect of blend type and blend ratio on the percentage of elongation for different shade depth blended melange yarns is illustrated in Figure 3.

It is evident from Figure 3 that:

– cotton-bamboo viscose blended yarn shows the highest percentage of elongation, followed by cotton

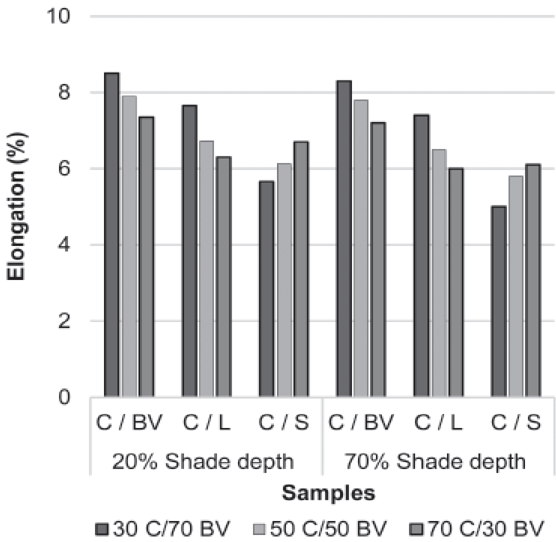

Figure 3: Effect of blend type and blend ratio on breaking extension

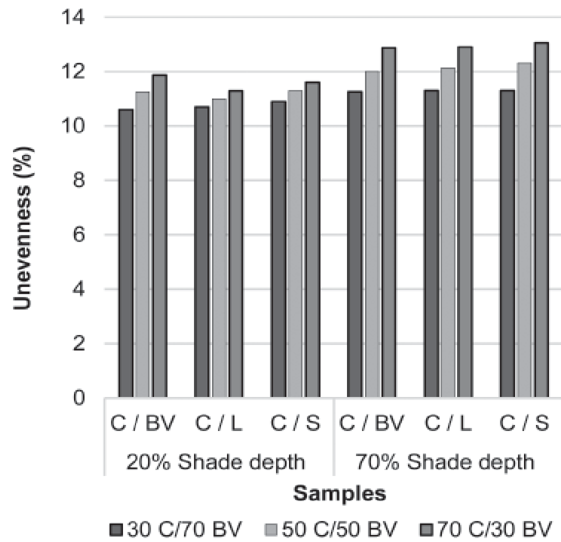

Figure 4: Effect of blend type and blend ratio on unevenness

lyocell and cotton-SeaCell™ blended yarns for all type of samples;
- the percentage of elongation decreases as the ratio of cotton increased; and
- 70% shade depth melange yarn demonstrates the lowest percentage of elongation.

Because fibre elongation properties directly affect yarn elongation, higher elongation values of regenerated fibres result in high elongation values in all 30/70 blended melange yarns. Cotton- lyocell blend yarns demonstrated the lowest percentage of elongation, while it is also evident from Table 1 that lyocell fibre showed a lower elongation than all regenerated fibres. It is evident that a high number of dyed fibres are present in the yarn cross section for high depth melange yarn and, similar to tenacity, they will reduce the percentage of elongation.

3.2 Unevenness of melange yarn

Unevenness (U expressed in %) shows the mass irregularity per unit length in the yarn. No significant difference in unevenness is observed for the type of blend. This may be due to the almost identical production process and the dimensional properties of all three regenerated fibres. Blend ratio and shade depth had a significant impact on the unevenness of melange yarns (Table 3). Figure 4 illustrates in graphical form the effect of blend type and blend ratio on the unevenness of different shade depth blended melange yarns.

It is evident from Figure 4 that:
- an increase of the cotton fibre contribution leads to the high unevenness of the yarn irrespective of other factors; and
- unevenness of darker melange yarns is higher than that of low depth melange yarns.

The arrangement of fibres and fibre properties influence yarn characteristics. Cotton is a naturally grown fibre, and is highly variable in terms of length and fineness relative to regenerated fibres. Cotton fibres are shorter in length than regenerated fibres (Table 1). Any variation in the fibres negatively affects the mechanical and physical properties of yarn. As the percentage of cotton increases, the availability of shorter fibres increases in the spinning system and decreases mean fibre length in the yarn structure, so that consolidation at the nip point during yarn manufacturing is lesser, which generates a greater amplitude of drafting waves. Mass irregularity thus increases.

Opening difficulties are seen more in high shade depth melange blends, as they consist of more dyed fibres. These difficulties cause the uncontrolled and erratic movement of fibres in the drafting area and eventually result in increased yarn mass variation.

3.3 Total imperfection of melange yarn

The imperfection index (IPI) consists of thin, thick and neps per unit length of yarn. Blend type, blend ratio and shade depth had a significant impact on the total imperfection of blended melange yarn (Table 3). Figure 5 illustrates in graphical form the effect of fibre blend type and blend ratio on total imperfection.

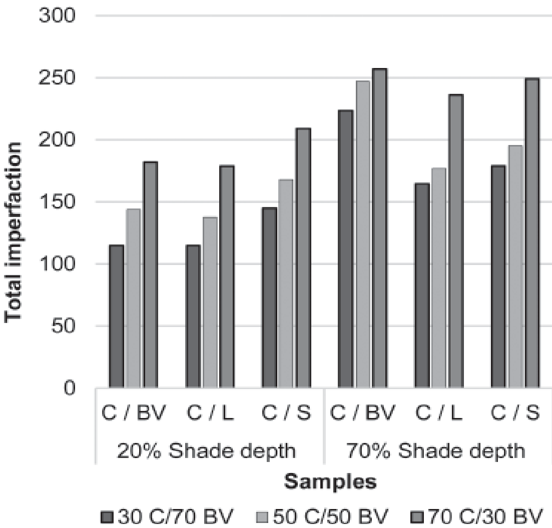

Figure 5: Effect of blend type and blend ratio on total imperfection

It is evident from Figure 5 that:

- a higher percentage of cotton leads to an increase in the total imperfection level in blended melange yarn;
- cotton-bamboo blend yarn demonstrates the highest and cotton-lyocell blended yarn the lowest total imperfection; and
- total imperfection increases with an increase in shade depth irrespective of blend type and blend ratio.

Regenerated fibres are known to have more a uniform shape and size in their longitudinal direction, while cotton fibres show a twisted structure. Simultaneously blended yarn with higher regenerated fibres consists of fewer shorter fibres and a higher mean fibre length, so that control over the movement of fibres is easy and imparts better association and orientation in yarn structure. Hence, higher cotton contribution leads to an increase in the total imperfection level in blended melange yarn.

The proportions of dyed fibres are higher in the high shade depth melange yarns. Dyeing changes the surface properties of the fibres, damages the fibres and increases fibre-to-fibre friction due to the removal of natural wax [23]. High fibre-to-fibre friction causes difficulties in the opening and drafting of fibres, which ultimately leads to the poor arrangement and distribution of fibre in yarn. Thus, higher yarn imperfections are seen for darker shades.

3.4 Hairiness of melange yarn

The hairiness of a yarn is the result of fibre protrusion from the yarn surface. Hairiness in spun yarn depends primarily on fibre properties such as the length, shape and bending rigidity of fibres. The effect of blend type, blend ratio and shade depth on the hairiness of melange yarn is significant (Table 3).

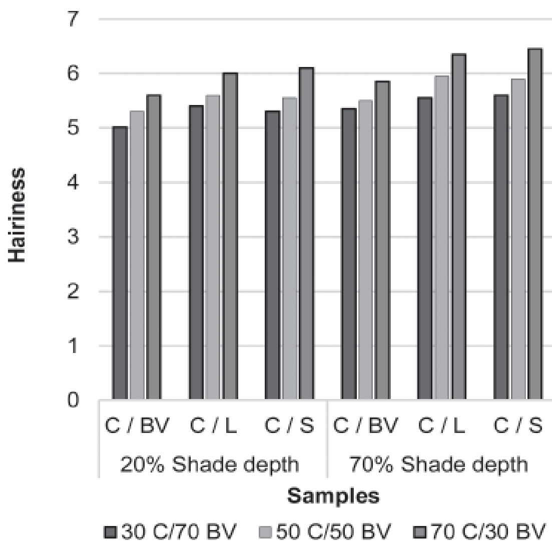

Figure 6: Effect of blend type and blend ratio on hairiness

It is evident from Figure 6 that:

– hairiness of melange yarn increases with an increase in the percentage of cotton in blended melange yarn;
– cotton-lyocell and cotton-SeaCell™ blended yarns demonstrate a marginal difference, while cotton-bamboo viscose blended yarn shows the lowest hairiness; and
– hairiness of melange yarn increases with an increase in shade depth.

Bamboo viscose, lyocell and SeaCell™ fibres have a longer length than the cotton fibres. Moreover, short fibres are totally absent in the all three fibres. The flexural and torsional rigidity of all three fibres are also lower than that of cotton fibre. Regenerated fibres are thus wrapped and adhered with the internal structure of melange yarn in the twisting triangle. As a result, hairiness decreases with an increase in the proportion of regenerated fibres.

The cross-section of lyocell and SeaCell™ fibre is round and the surface is smooth, while bamboo viscose fibre has an irregular and toothed shape [13]. On the other hand, bamboo viscose fibre shows a lower torsional rigidity than lyocell and SeaCell™ fibre. These properties of bamboo viscose fibres cause higher inter-fibre friction, while a better consolidation of surface hair in the main yarn structure ensures low hairiness.
The chemical and mechanical processing of fibres in melange yarn manufacturing causes rupture and high short fibre generation. Short fibres have a tendency to come out from the yarn body and do not wrap with the main body of melange yarn during twisting. Moreover, control over the short fibres is also difficult during drafting. High depth melange yarn consists of more such fibre, which results in a high level of hairiness.

3.5 Diameter of melange yarn

The surface characteristics and appearance of a yarn influence the appearance of products made from that yarn. No significant difference in the diameter is observed for the shade depth. The type of fibre and blend ratio have a significant impact (see Table 3). Figure 7 illustrates in graphical form the effect of blend type and blend ratio on diameter for different shade depth blended melange yarns.
It is evident from Figure 6 that:
- diameter of melange yarn increases with an increase in the percentage of cotton in blended melange yarn; and
- cotton-lyocell blended yarn shows the lowest diameter, followed by cotton-SeaCell™ and cotton-bamboo viscose blended yarn.

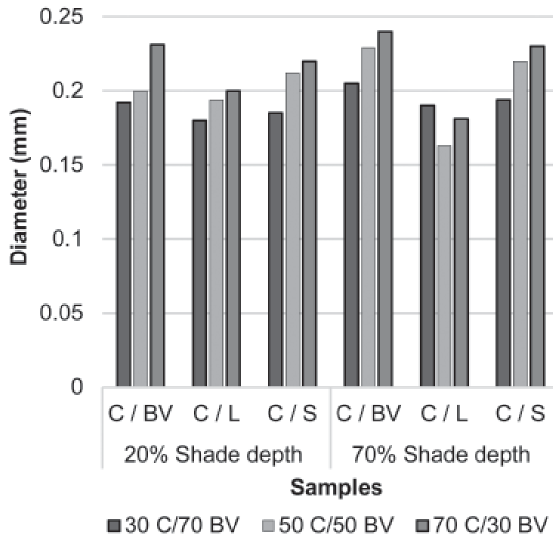

Figure 7: Effect of blend type and blend ratio on diameter

Yarn diameter steadily increases with an increase in the percentage of cotton in the yarn composition. As discussed, all of the regenerated fibres have a longer length (38 mm) than that of cotton fibres. Moreover, they have lower bending and torsional rigidity than cotton fibre. On the other hand, the non-circular cross-section of cotton does not allow close association. Thus, fewer cotton fibres in the cross section lead to closed packing in the melange yarn structure and high diameter in cotton-rich blends.
Figure 8 is a microscopic image of blended melange yarns, which shows that lyocell-blended yarn has a compact internal structure and better integrity and thus a lower diameter. On the other hand,

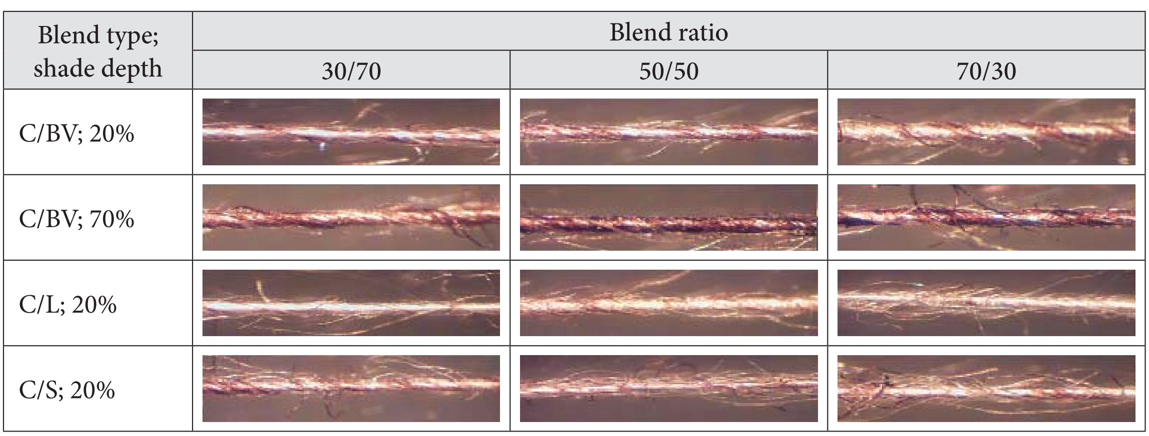

Figure 8: Microscopic image of blended melange yarn

bamboo-blended melange yarn has a more uniform surface and lesser protruding fibres from the main body, while the fibres are rather protruded on the surface in the case of lyocell- and SeaCell™-blended yarns. Bamboo viscose blended yarn thus shows low hairiness.

3.6 Surface friction

Basic yarn properties such as linear density, evenness and strength do not fully account for processing performance and/or fabric quality. Friction plays vital role in expressing interactive behaviour for fibre-to-yarn and yarn-to-fabric modelling. The resistance to movement, characterised by the coefficient of friction, is dependent on the nature of the two contacting surfaces and their actual area of contact. Figure 9 illustrates in graphical form the effect of blend type and blend ratio on the coefficient of friction for different shade depth blended melange yarns.

It is evident from Figure 9 that:

- increase in the percentage of cotton leads to lower value of coefficient of friction;
- cotton-bamboo viscose blended melange yarn shows the highest coefficient of friction, while the differences between cotton-SeaCell™ and cotton-lyocell blended yarns are not significant; and
- the value of the coefficient of friction is marginally higher for high depth melange yarn.

As discussed, increasing the percentage of cotton in the blended melange yarn structure leads to high hairiness values. The same is also evident from Figure 8. On the other hand, cotton fibres have a natural wax that serves as a lubricant when they come in contact with other surfaces. Hence, cotton-rich blended varn shows a lower coefficient of friction.

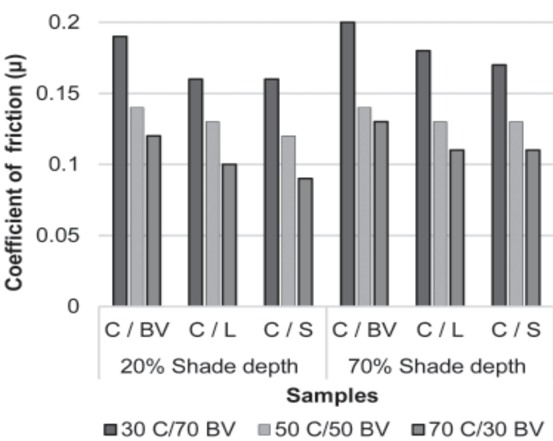

Figure 9: Effect of blend type and blend ratio on coefficient of friction

The frictional characteristics of parent fibres have an impact on the frictional characteristics of blended yarn. Microscopic images show that the surface of bamboo-blended yarn is more uniform and less hairy than SeaCell™- and lyocell-blended yarns (Figure 8). Due to their yarn structure, bamboo-blended yarns show a high coefficient of friction.

In dyeing process, cotton fibre is subject to a scouring process that removes the lubricating layer. The removal of cotton wax increases the coefficient of friction due to underlying rough surface of the layer. On the other hand, the presence of short fibres increases the voluminous of the high depth melange yarn, making the yarn bulkier, which is also evident from Figure 8. Bulkier yarn is more compressible and flattens easier, so the scope of flattening increases when passed over any surface. Hence, higher coefficient of friction values are demonstrated by darker melange yarn.

4 Conclusion

The analysis of the study presents an overview of cotton-bamboo viscose, cotton-lyocell and cotton-SeaCell™ blended melange yarn characteristics, such as strength, elongation, unevenness, hairiness, diameter and friction.

The following conclusion can be reached from the experiments:

- Type of blend, blend ratio and shade depth have a significant affect on blended melange yarn quality. An evaluation of the effect of shade depth on blended melange yarns shows a reduction in strength and elongation. The dyeing and opening of bamboo viscose fibres causes a reduction in strength of up to 9.48%. The lower depth melange yarn contributes to the production of good quality yarns with significantly reduced hairiness and improved mechanical and frictional characteristics.
- Cotton-rich blended yarns show lower friction and elongation, and higher hairiness, total imperfection and unevenness, irrespective of the type of blend. Increasing the cotton content in bamboo- and SeaCell™-blended melange yarns increased tenacity. However, lyocell-blended yarns show the opposite trend.
- Cotton-bamboo blended yarns show the highest diameter and lowest hairiness in all the combination of yarn samples. Cotton-lyocell 30/70 blended yarn gives the strongest blended melange yarn among the studied yarn samples.

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