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Effect of Blending Methodologies on Cotton Mélange Yarn Quality

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Abstract
Fibre of dyed mélange yarn is becoming an emerging product in the field of textiles. The quality of mélange yarn is largely influenced by the types of blending methodologies. There exists hardly any reported work where the effect of blending methods on cotton mélange yarn quality has been studied. The purpose of this paper is to investigate the effect of blending methodologies on the properties of cotton mélange spun yarn. Dyed and grey cotton fibre components were mixed at the blow room and draw frame stages separately to produce mélange yarns with three different shade depths (%). Better yarn quality with respect to yarn evenness, imperfections, tenacity, elongation at break and hairiness index was achieved with the draw frame blending methodology as compared to the blow room blending methodology. The mélange yarn quality deteriorates with an increase in shade depth (%) for both blending methodologies.

Key words: *blow room blending, draw frame blending, fibre breakage, mélange yarn, shade depth, yarn quality.*

Introduction

With the advent of technology, the textile industry is now capable of producing various kinds of yarns and fabrics with special appearance by varying the product mix and structure. Nowadays, yarns with structural effects like waves, loops, chenille, pile, etc. and optical effects like colour and lustre or dull outcomes are becoming lucrative products of spinning, twisting, wrapping, texturing, printing, knitting etc. [1]. Fancy yarns exist on the textile market as a main raw material for hosiery and woven products, and there is more demand for fancy yarns in the era of modern fashion [2]. Among the various fancy yarns, mélange yarns are known for their attractive colour and appearance. Mélange yarn is made out of two or more different coloured fibres which are spun after mixing, therefore creating a unique mixed colour effect. Such types of fancy yarns have advantages for fabric appearance and can be used in casual wear, sportswear, shirts, business suits, socks and all sorts of clothing products, as well as in bed linens, towels, decorative fabrics and other home fabric products. Gong and Wright [3] mentioned that fancy yarns are the big classification of yarns that are being used as having something more special than conventional yarn. The extent of fibre damage was assessed by Moghassem [4], who noted that the fibre length by number and weight of grey cotton was more than those of dyed cotton, while the quantity of fibre neps and short fibre content of dyed cotton were more than those of grey cotton. He concluded that the repetition of mechanical action on the fibre involved in melange yarn manufacturing causes damage to the fibre. Koo et al. [5] noted that the fibre damage during the dyeing process degrades the physical properties of speciality yarn. Ishtiaque and Das [6] observed that dyed cotton fibre length and related parameters consistently deteriorate at each mechanical processing stage of the rotor spinning process, and that the effect is more prominent in the case of natural dyed cotton fibres due to the higher frictional coefficient. Karim et al. [7] made a comparative study of the properties of ring spun and rotor spun cotton mélange yarns and found less loss of mechanical properties of ring spun mélange yarn than for rotor spun mélange yarn. Naik and Bhat [8] observed that the dyeing process of cotton fibres leads to greater entanglement and cohesion among them and further mechanical processes to fibre damage, which makes the mélange yarn manufacturing process more difficult. An increase in the dyed fibre share in the mixture further increases difficulties in mélange yarn manufacturing. In mélange yarn manufacturing the major problem of shade variation was discussed by Yinggang [9]. Zou [10] studied the effect of process variables on the properties of air vortex spun mélange yarn made from viscose fibres and observed that vortex mélange yarn quality is largely affected by the yarn delivery speed, yarn count and nozzle pressure. Memon et al. [11] studied the impact of cotton fibre dyeing parameters on mélange yarn properties like yarn evenness, imperfection, strength, elongation and hairiness, and they emphasised the optimisation of dyeing parameters for better mélange yarn properties. Regar et al. [12] reported that compact mélange yarn exhibited better mass uniformity, strength and elongation as well as less hairiness and coefficient of friction compared to conventional ring spun cotton mélange yarn. Chollakup et al. [13] found that the blended fibres in draw frame blending tend to migrate more towards the yarn core as compared to intimate blending. Intimate blending gave a more homogeneous fibre distribution, with no radial migration tendency. Lam et al. [14] pointed out that the blending method of fibre components (fibre or sliver blending) directly influences the yarn tenacity. They also informed that fibre blending offers more evenness in fibre distribution in the spinning process as opposed to the sliver blending method. Mahmood et al. [15] studied the effect of bleaching on the tensile properties of dyed polyester and bleached cotton blended melange yarns and observed that the yarn tensile properties improve gradually as the share of polyester in the blend increases. Prakash et al. [16] studied the effect of the blend ratio on the quality of bamboo/cotton blended yarn and observed that increasing the content of bamboo fibre led to a reduction in overall yarn properties. Zou [17]

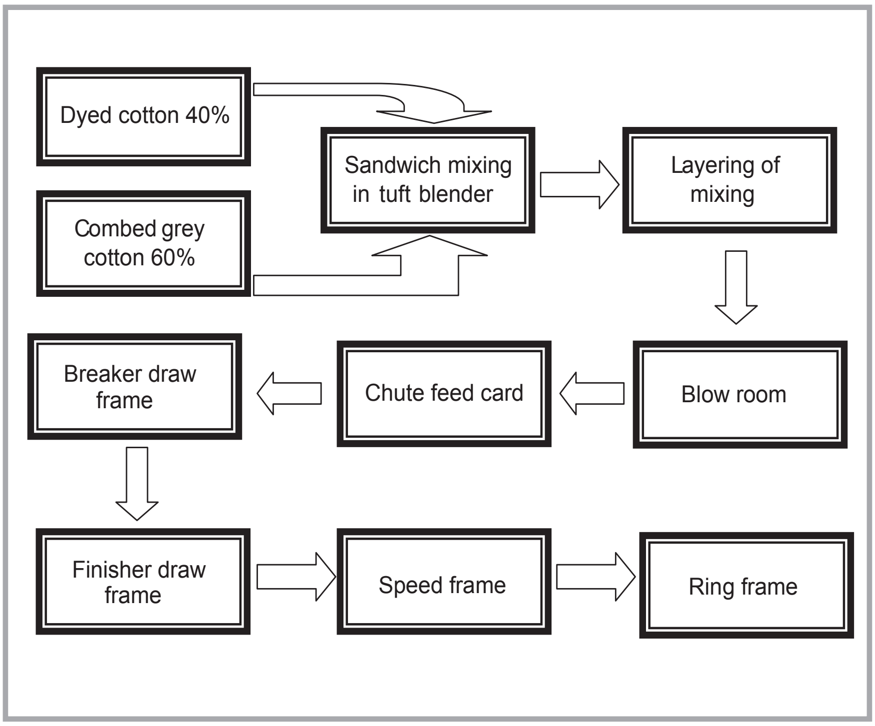

Figure 1. Process flowchart for blow room blending (shade depth – 40%).

pointed out that the yarn formation process variable in the case of vortex spun melange yarn largely affects fabic characteristics such as the air permeability rate, dynamic drape co-efficient, fabric breaking strength. Vadicherla and Sarvanan [18] investigated the effect of the blend ratio on the quality characteristics of recycled polyester/cotton draw frame blended ring spun yarn. They observed that an increase in recycled polyester content increases the tenacity, elongation at break and hairiness and decreases unevenness, thin places, thick places, neps and hairiness.

There are two methods of blending to produce cotton mélange yarns, viz., blow room blending and draw frame blending. A survey of literature shows that there are hardly any reports on the effect of blending methods on cotton mélange yarn quality. This study was therefore undertaken to investigate the effect of blending methodologies and blending

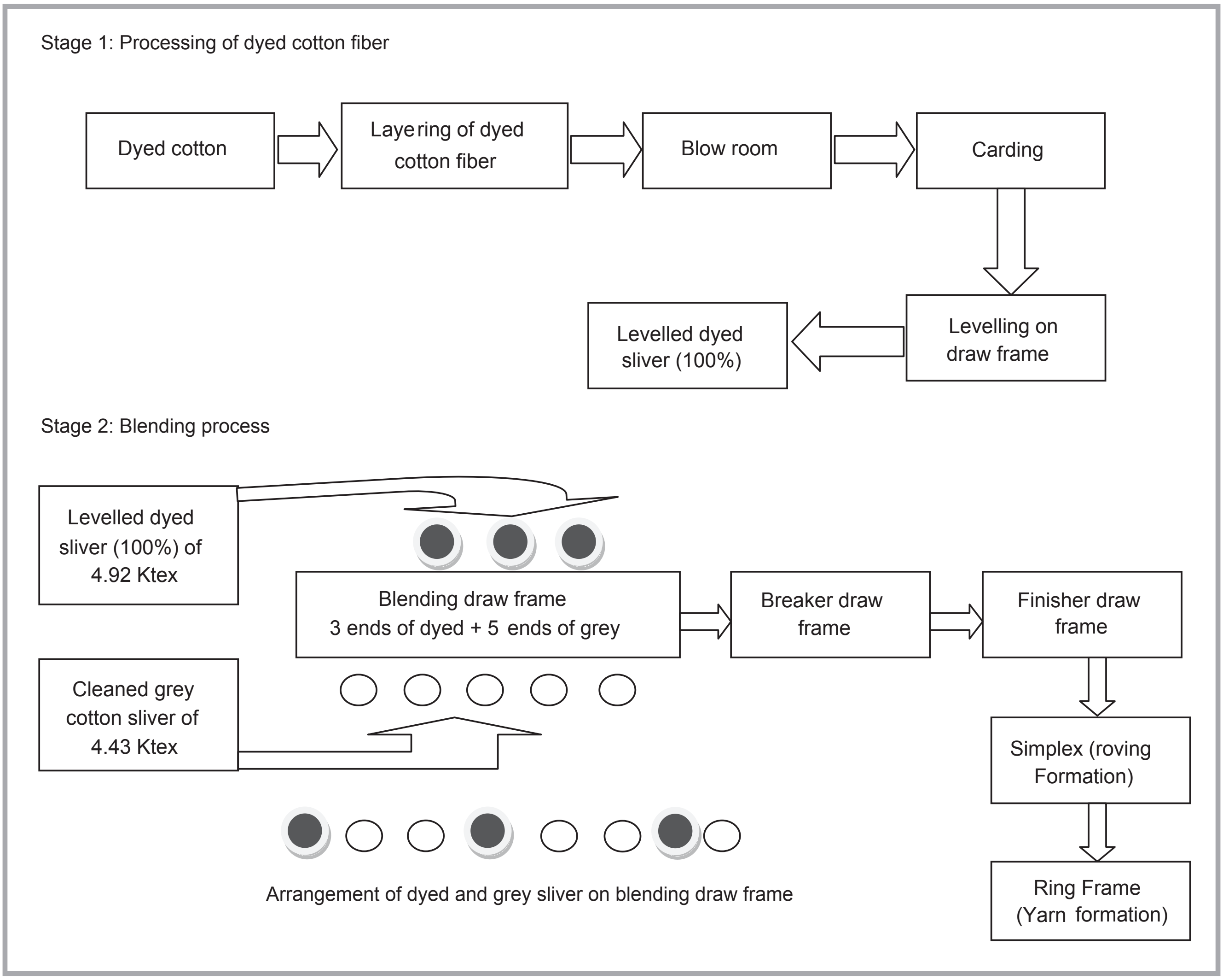

Figure 2. Process flow chart for draw frame blending (shade depth – 40%).

stages at different shade depths (%) on the properties of cotton mélange yarn.

Materials and methods

Cotton mélange yarn manufacturing process

The mixing of dyed and un-dyed (grey) cotton fibres in various ratios produces a variety of mélange yarns. This mixing of fibres (dyed and un-dyed) could be done either at the blow room stage or draw frame stage to create the mélange effect in the yarn. In the case of mélange yarn production, the percentage of dyed fibre in the mixing is commonly termed as the shade percentage or shade depth (%). Depending upon the stages of mixing of dyed and grey cotton, mélange yarn manufacturing methods are classified in two types, namely blow room blending and draw frame blending.

Process flow of blow room blending

Normally darker shades and ones consisting of a variety of coloured fibres are run as blow room blend shades. Conventionally, shades having a depth more than 40% are run as blow room blends. As the mixing of dyed and grey components is done in the initial process of manufacturing, the chances of fibre randomisation and homogeneous blending are higher in the case of the blow room blending method. Consequently better shade/colour uniformity in appearance is achieved in the case of the blow room blending method, which is basically a single stage manufacturing process. ***Figure 1*** depicts the process flowchart for the blow room blending method for producing mélange yarn of 40% shade depth.

Table 1. Fibre quality parameters.

Material	HVI test results			Bare sorter analysis	
	Length, mm	Bundle strength, g/tex	Short fibre index, SFI	Effective length, mm	Short fiber content, %
Grey combed fiber	27.59	32.6	6.6	33	10.32
Dyed combed fiber	27.47	20.43	6.7	33	10.73
Carded dyed fiber	26.71	16.37	8.5	32	14.62
Mixing fiber of 40% shade	26.70	26.5	6.7	33	11.06
Card sliver of 40% shade	26.06	22.2	6.2	32	16.12

Table 2. Process parameters used for melange yarn preparation.

Count, tex	Ring frame		
	Shade depth, %	Spindle speed, rpm	Yarn TM
30	10	14500	3.7
	40		
	70		

Process flow of draw frame blending

Mostly lighter shades having a shade depth less than 40% are blended on the draw frame as they are easy to blend and produce good shade appearance. Draw frame blending is basically a double stage manufacturing process. ***Figure 2*** illustrates the process flowchart for the draw frame blending method for producing mélange yarn of 40% shade depth. Stage 1 in ***Figure 2*** illustrates the process flow chart for dyed fibre preparation. The blending of dyed and grey slivers was done on a blending draw frame. Stage 2 in ***Figure 2*** schematically represents the blending of dyed and grey slivers on a blending draw frame and flow chart of the subsequent processes for producing mélange yarn of 40% shade depth.

Materials and preparation of yarn samples

Black dyed and grey combed Sankar 6 cotton fibres were used to produce 30 tex (20^s Ne) mélange yarns. The cotton fibre properties used to produce the yarns are summarised in ***Table 1***. The process flow charts depicted in ***Figure 1*** and ***Figure 2*** were used to produce blow room blended and draw frame blended cotton mélange yarns, respectively. For each type of blend, yarn samples were prepared for three different shade depths %, viz., 10%, 40% and 70%. All the yarn samples were prepared in a conventional ring spinning system. The process parameters used to produce the yarns are summarised in ***Table 2***.

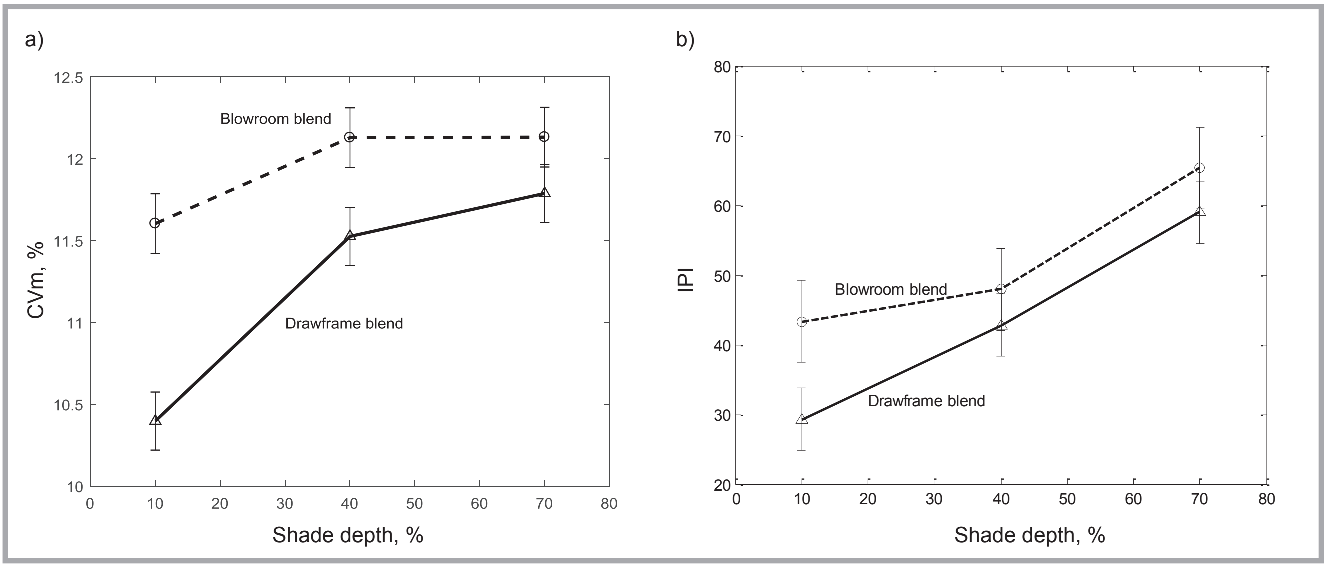

Figure 3. *a) Effect of shade depth (%) on unevenness (CVm), and b) effect of shade depth (%) on imperfections (IPI) for blow room and draw frame blended mélange yarn.*

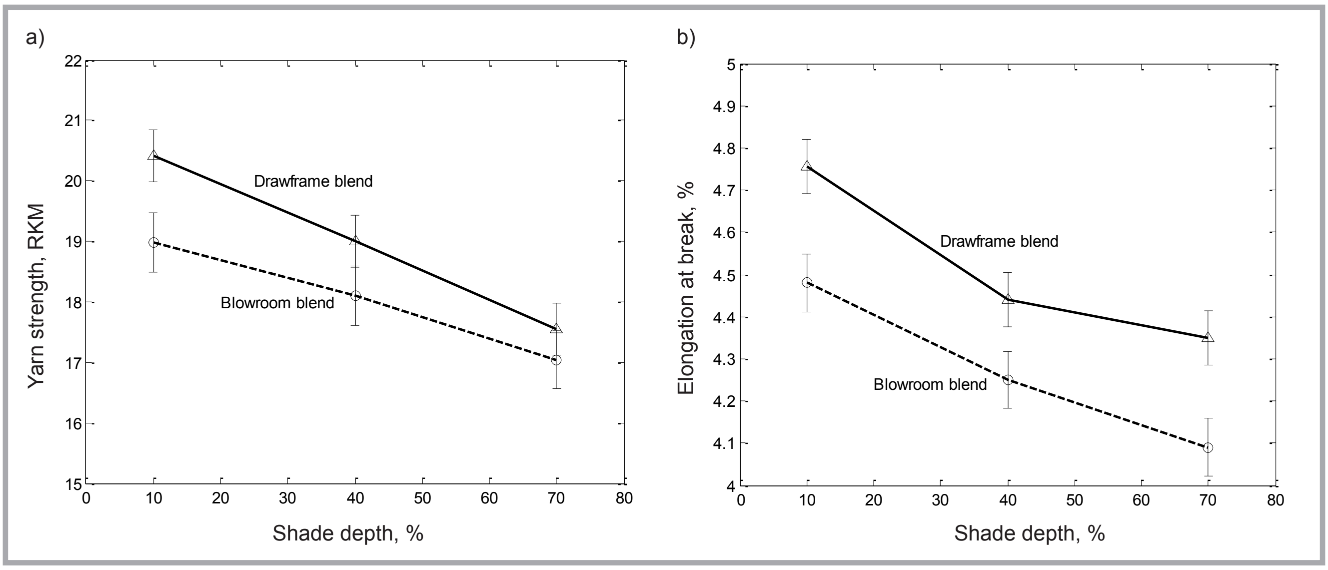

Figure 4. *a) Effect of shade depth (%) on strength (RKM), and b) effect of shade depth (%) on elongation at break (%) for blow room and draw frame blended mélange yarn.*

Testing of yarn samples

All yarn samples were placed for 24 h in standard atmospheric conditions in order to balance the humidity effect. Grey combed fibre and dyed combed fibre were tested for their length and strength parameters using HVI 900 (Zellweger, Switzerland) and Bare Sorter instruments. Subsequently the samples were evaluated for yarn unevenness (CVm), imperfections (IPI), the hairiness index (HI), tenacity (cN/tex) and breaking elongation (%). Yarn CVm, IPI and HI were tested with a capacitance based evenness tester (USTER® TESTER 4, Zellweger, Switzerland) at a yarn withdrawal speed of 400 m/min for a testing time of 1 min. Yarn IPI is estimated as the sum total of the number of +50% thick places, -50% thin place and +200% neps per Km length of yarn. For each type of yarn, 10 readings were taken to measure the average CVm, IPI and HI. Tensile properties of the yarns were tested by means of an Uster Tensojet tensile tester (Zellweger, Switzerland) using a specimen test length of 500 mm, extension rate of 400 m/min and pre-tension of 0.5 cN/tex. The average yarn tenacity and breaking elongation were estimated for each type of yarn based on 1000 readings.

Results and discussions

The experimental values of yarn evenness, tenacity, elongation at break, imperfections (IPI) and hairiness index of 30 tex (20^s Ne) cotton mélange yarns prepared with the blow room and draw frame blending techniques are tabulated in ***Table 3***.

Yarn evenness (U %) and imperfections

The effect of shade depth on yarn unevenness (CVm) and imperfections (per km) for blow room blended and draw frame blended cotton mélange yarns is shown in ***Figure 3.a*** and ***3.b,*** respectively. It is observed from ***Figure 3*** that yarn unevenness and imperfections increase as the shade becomes darker for both the types of blending methodology. The average yarn CVm and imperfections for blow room blended mélange yarns are significantly higher than those of draw frame blended mélange yarns for all shade depths %.

The process flow charts for mélange yarn production for both types of blending techniques, shown in ***Figure 1*** and ***Figure 2,*** clearly indicate that the entire grey cotton fibre used in the mélange mixture is actually processed twice through the blow room and carding machines in the case of blow room blending. In order to produce blow room blended mélange yarn, firstly the grey fibre is opened and cleaned by processing from the blow room to the comber separately, then they are mixed with the dyed fibre (amount depending upon the shade depth %) in the tuft blender, followed by subsequently processing though the blow room and card. Hence for blow room blending, the chances of short fibre generation due to fibre breakage and formation of fibrous neps and entanglements increase with the excessive mechanical action and fibre transportation through the pipelines. Once the fibre mix (dyed and grey) is processed through the card, there is no further scope available for removing the short fibre and entanglement in the next processes of yarn manufacturing. Thus the reduction in effective fibre length and higher proportion of fibrous neps and entanglement are eventually reflected in terms of yarn unevenness, thick places, thin places and neps. On the other hand, in the case of the draw frame blending method, the grey fibre is treated sepa-

Table 3. *Experimental results of mélange yarn properties for different blending techniques.*

Yarn properties	Type of mélange yarn	Shade depth, %		
		10	40	70
CVm, %	Blow room blended	11.60	12.13	12.14
	Draw frame blended	10.4	11.53	11.79
Strength, RKM	Blow room blended	18.98	18.11	17.04
	Draw frame blended	20.42	19.00	17.55
Elongation at break, %	Blow room blended	4.48	4.25	4.09
	Draw frame blended	4.76	4.44	4.35
Imperfections per Km, IPI	Blow room blended	43.32	47.92	65.40
	Draw frame blended	29.23	42.73	59.02
Hairiness index, HI	Blow room blended	4.27	4.76	5.26
	Draw frame blended	4.10	4.36	5.16

rately up to the combing stage only once before mixing with dyed cotton at the draw frame stage. Therefore the amount of short fibre and number of fibrous neps present in the grey cotton part are much less. Moreover the dyed fibre sliver passes through the draw frame stage four times in the case of the draw frame blending method as compared to only two times in the case of the blow room blending method. More drawing passages improves the effective length of fibre; therefore draw frame blended mélange yarn shows better yarn evenness and imperfections than those of blow room blended mélange yarn.

An increase in the shade depth % has a detrimental influence on CVm and imperfections for both blow room and draw frame blended mélange yarns. This is attributed to the fact that the change in the surface characteristics of fibre after dyeing causes an increase in fibre entanglement and fibre-to-fibre friction. As a consequence, opening and drafting become more difficult while processing a higher percentage of dyed fibres. Therefore a higher shade depth % deteriorates mélange yarn quality in terms of CVm and imperfections.

Yarn strength and elongation at break

Figure 4.a and ***4.b*** depict the effect of the shade depth (%) on cotton mélange yarn strength and elongation at break, respectively, for both types of blending method. The strength and breaking elongation of draw frame blended yarns are observed to be higher than those of blow room blended yarn for all levels of shade depth (%).

It has been discussed in the earlier section that the chance of fibre breakage is more evident for the blow room blending method as compared to the draw frame blending method. The generation of short fibres increases proportionately with the fibre breakage. When a yarn is subjected to tensile testing, short fibres present in the yarn are more prone to slip, resulting in lower yarn strength and breaking elongation. In addition, a higher number of drawing passages imparted in the draw frame blending technique improves the effective fibre length because of more parallelisation, which also contributes towards the improvement in yarn strength and elongation at break.

The reduction in mélange yarn tensile properties as the shade becomes darker for both methods of blending may be ascribed to the higher proportion of weak dyed fibre content in the yarn cross-section. The cotton fibre strength decreases during the dyeing process and weak dyed fibres are more prone to damage during the mechanical processing in spinning. ***Table 1*** depicts the HVI and Bare Sorter results for fibre strength and length parameters of combed grey fibre and combed dyed fibre. It is clearly evident from ***Table 1*** that the dyeing of cotton fibre causes a 37.3 % loss of fibre bundle strength. Hence yarn strength and elongation at break decrease at a higher shade depth (%).

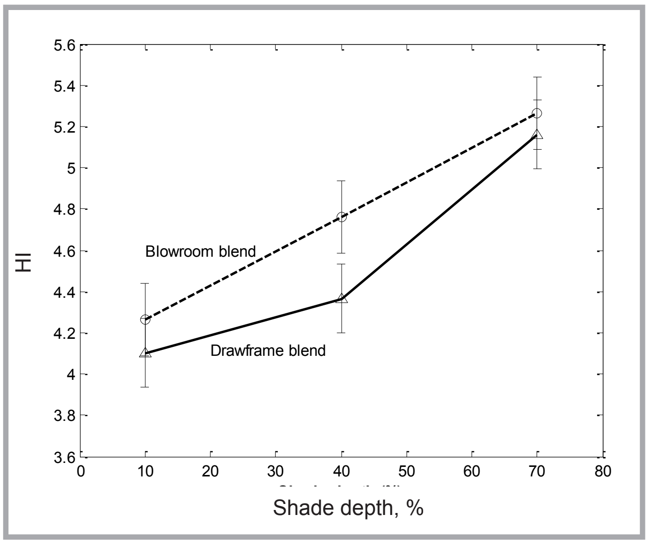

Figure 5. *Effect of shade depth (%) on hairiness index (HI) for blow room and draw frame blended mélange yarn.*

Yarn hairiness index

The effect of shade depth on the yarn hairiness index for blow room blended and draw frame blended cotton mélange yarn is shown in ***Figure 5***. It is noted from ***Figure 5*** that the yarn hairiness index increases with an increase in the shade depth (%) for both methods of blending. The difficulty of fibre opening during the mechanical processing of dyed fibres causes a higher chance of fibre breakage, which, in turn, generates more short fibres. The presence of a higher number of short fibres increases the number of protruding fibres on the yarn surface. Moreover after dyeing, the fibre becomes coarser, and coarser fibres have a tendency to migrate on the outer surface of the yarn body during spinning. This phenomenon may be a cause of higher hairiness at darker shades.

The higher hairiness index for blow room blended cotton mélange yarn is ascribed to the presence of a higher number of short fibres, which, in turn, increases the protruding fibres on the yarn surface.

Conclusions

Cotton Mélange yarn quality is significantly affected by the method of blending. Better mélange yarn quality is achieved with the draw frame blending techniques than with the blow room blending technique. Repetitive blow room and carding action imparted in the blow room blending method causes more fibre damage and higher short fibre generation, which results in lower yarn strength and breaking elongation, as well as more yarn unevenness, imperfections and hairiness. Furthermore a higher number of draw frame passages improves fibre parallelisation, which results in better yarn quality in the case of draw frame blending methodology. Mélange yarn quality significantly deteriorates with an increase in shade depth (%) for both types of blending techniques.

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