TECHNOLOGICAL STUDY OF RING AND COMPACT SPINNING SYSTEMS FOR THE MANUFACTURING OF SLUB FANCY YARN UNDER MULTIPLE SLUB VARIATIONS AND ITS EFFECT ON WOVEN FABRIC

Nasir Mahmood[1]*, M. Arshad[2], M. Iftikhar[1] and Tahir Mahmood[1]

[1]Department of Fibre Technology, University of Agriculture, Faisalabad
[2]Department of Irrigation and Drainage, University of Agriculture, Faisalabad
*Corresponding author's e-mail: nasirmahmood23uaf@yahoo.com

Textile technologies are continuously evolving with the objects both of increasing productivity and reducing processing costs, and of creating new products or variants of existing ones. Fashion, in the widest sense of the word mean fulfillment of consumer demands, through the ages constitutes a fundamental and conditional element for the whole textile industry. Fancy yarns present deliberate, decorative continuous or programmed effects of colour and/or form; they are used to create some variation in the aesthetic appearance of a fabric. The drafting process is deliberately interrupted through the effect yarn device to produce slubs in the final yarn. The present research study was aimed to evaluate the quality characteristics of slub fancy yarn by changing slub length, inter slub distance, slub thickness and twist multiplier (T.M) at ring and compact spinning systems.

Keywords: Compact and ring spinning, slub fancy yarn, fabric

INTRODUCTION

Fancy yarn is a textile yarn with virtually unlimited pattern designs. Fancy yarns present deliberate, decorative continuous or programmed effect of Coloures and are used to create some variations in the aesthetic appearance of a fabric or garment. Fancy yarns differ from the normal construction of single and folded yarns by way of deliberately produced irregularities in its construction. These irregularities relate to an increased input of one or more of its components, or to the inclusion of periodic effects, such as knops, loops, curls, slubs, or the like. Some of the effects which could be produced using the ring spinning system are slub, loop, gimp, boucle, spiral, corkscrew, eccentric, button etc. The fundamental features of all these effects are the variations in delivery speed. These yarns are used in modern fabric to produce a natural, rustic and attractive character of the product. Slub yarn is a kind of fancy yarn, whose slub appearance is gained by the variation of the yarn linear density during the spinning process and because of its special appearance, has been widely used in a variety of garments.

There are numerous technologies that can be used to create fancy yarns. Some of these technologies include machinery such as hollow-spindle machinery, chenille machines, ring-spinning and rotor-spinning frames, folding/cabling machinery, and specialized machines. Ring spinning is still regarded as the "standard spinning method" against which all other yarn production systems and compared (Gong and Wright, 2002). Count and twist have considerable influence on yarn hairiness. Yarn hairiness bears a close correlation with irregularity, with coarser regions having more hairiness than finer portions. The yarn from thick band is found to be more hairy. In the slub fancy yarn slub portions have more hairiness than base yarn because of higher number of fibres in cross-section.

In compact spinning, a condensing zone is introduced after normal drafting zone. As a result, the strand width becomes closer to yarn diameter and the size of spinning triangle is considerably reduced. Fibres get fully integrated into yarn and projecting fibres are markedly reduced. In normal yarns projecting fibres do not fully contribute to yarn strength. When these fibres are fully integrated into yarn as in compact spinning their contribution to yarn strength and elongation improves. This is the reason for the increase in strength and elongation of yarn in compact spinning.

The basic principle of producing slub fancy yarn is based on roller drafting system. The drafting process is deliberately interrupted to produce thick places at random intervals in the final yarn (Lawrence, 2003). The high performance drive is designed with a specific amsler-device in customized combination with a new high-voltage servo motor regulator which is forced to run with extreme high frequencies of slubs per minute. The thick place in the yarn is followed immediately by a thin place, rather than by a simple return to the basic yarn count being spun. This, in turn, creates a weak place in the yarn. The slub effects of the amsler system are specially constructed to ensure that no thin spots develop after the slub. It is necessary to adjust the slub length to avoid basic yarn twist exceeding critical twist. Increased length of the slub leads to the increased twists of the basic yarn. Twists in every section of the

slub yarn are in inversely proportion to the square of the linear density of the corresponding section. In this concern the present research study was planed to examine how multiple process variables such as slub length, inter slub distance, slub thickness, yarn count and twist multiplier affect the fancy yarn properties.

MATERIALS AND METHODS

This present research study was initiated in the Department of Fibre Technology, University of Agriculture Faisalabad, and mainly conducted at Crescent Bahuman Ltd., Hafizabad during the year 2008. The complete description of the material used and the methods applied to test the quality characteristics of spun yarn and fabric are described here under.

Material used

Lint sample of cotton variety MNH-93 were collected from the running stock of the mills. All the yarn samples prepared were subjected to the following characteristics by using standard techniques and the data was recorded for statistical interpretation.

Yarn count

The yarn count was estimated through "Skein Method", according to ASTM standard (1997a) with the help of Uster auto sorter.

Yarn lea strength

Yarn lea strength was also determined by "skein Method" recommended by ASTM Committee (1997a) according to standard method by using pendulum type lea strength tester.

Weaving process

The yarn samples were then used in the weft of the fabric on a power loom. Samples were wound on bobbins by using a winder to use in weft direction. Warp was kept constant for all fabric samples. Warp and weft count was; 9^s. The woven fabric was evaluated for the tensile parameters of the fabrics.

Tensile strength of fabric

The Testeron Electronic Tensile Tester STE-1000 was used for the tensile strength testing. The method was adopted as mentioned in ASTM (1997b).

Analysis of data

The data thus obtained have been analysed statistically by applying analysis of variance technique, while DMR test was applied for individual comparisons as suggested by Faqir (2004) using M-Stat micro computer package devised by Freed (1992).

RESULTS AND DISCUSSION

Yarn count

The statistical analyses of data regarding yarn count indicate significant difference in the mean values of yarn count due to different twist multipliers (T). Whereas, non-significant differences were recorded for spinning system (S), slub length (L), inter slub distance (D), slub thickness (W) and all the remaining interactions.

The individual comparison of mean values of yarn count for spinning systems S_1 and S_2 presented in Table 1 show that both the values have non-significant difference with each other. The closest value was

Table 1. Comparison of individual mean values for yarn count (Ne)

Spinning System	Slub Length	Inter Slub Distance	Slub Thickness	Twist Multiplier
S_1= 9.25	L_1= 9.27	D_1= 9.23	W_1= 9.25	T_1= 9.41 a
S_2= 9.24	L_2= 9.24	D_2= 9.25	W_2= 9.25	T_2= 9.22 b
	L_3= 9.23	D_3= 9.26	W_3= 9.24	T_3= 9.11 c

Mean values having different letters differ significantly at 5% level of significance.

Counts lea strength product value (CLSP)

Count Lea Strength Product value was calculated by multiplying average count with respective average lea strength value of yarn.

Yarn evenness (U %)

Yarn evenness (U %) was determined by Uster Evenness Tester-IV (UT-4), the procedure for testing was derived from ASTM Standards (1997a).

obtained for compact ring spinning machine (S_2) as 9.24^s while the mean value for conventional ring spinning machine (S_1) is 9.25^s. Non-significant results indicate that both machines preformed equally better for yarn count. These results get support from the work of Saleem (2003) who observed that yarn count was not significantly changed by using modified and conventional ring spinning machines.

The comparison of individual means for slub length revealed that effect of slub length on yarn count was

non-significant. The highest value of yarn count 9.27^s is noted for L_1 (50mm) followed by 9.24^s and 9.23^s for L_2 (60mm) and L_3 (70mm) respectively. The individual comparison of mean values of yarn count for inter slub distance D_1, D_2 and D_3 presented in table 1, show that the values were non-significant with each other. The closest value was obtained for inter slub distance D_1 (170mm) as 9.23^s followed by 9.25^s and 9.25^s for D_2 (200mm) and D_3 (230mm) respectively. The individual mean values of yarn count for slub thickness W_1, W_2 and W_3 are 9.25^s, 9.25^s and 9.24^s respectively, which have non-significant differences from one another.

The individual mean values of yarn count for twist multipliers T_1, T_2 and T_3 were observed as 9.41^s, 9.22^s and 9.11^s respectively, which had significant differences from one another. Likewise, Jamil *et al.* (1998) reported that break draft affected significantly the yarn count as well as significant differences were found for yarn count due to twist multiplier. Whereas, Sharma *et al.* (1987) concluded that a slight variation in actual count obtained with different twists because as twist increases yarn becomes more compact.

Yarn lea strength

The statistical analysis of variance pertaining to yarn lea strength show highly significant effects due to spinning system (S), slub length (L), inter slub distance (D) and twist multiplier (T). While non-significant effects were obtained for slub thickness (W) and all the remaining interactions.

The individual comparison of mean values regarding yarn lea strength for different spinning systems S_1 and S_2 given in Table 2 shows that both the values have significant difference. The stronger yarn was obtained

and further stated that other than yarn hairiness, yarn parameters such as strength, elongation, imperfections and uniformity are also better than ring spun yarn.

As regarded to slub length (L) results revealed that highest value of yarn lea strength 258.32 Pounds was recorded for L_1 (50mm) followed by 254.65 and 251.28 Pounds for L_2 (60mm) and L_3 (70mm) respectively. The results indicate that slub length has significant effect on yarn lea strength. The values have significant difference with one another and results are fully supported by Ajmal (2005) who explained that slub length significantly affects the yarn count, lea strength and single end strength. However, the variation of slub thickness produced a non significant effect on most of the yarn properties. Likewise, Testore and Minero (1988) reported that parameters influencing the characteristics and appearance of slub yarn are metric count, average number of slubs per meter, average distance between consecutive slubs and slub length and there is a significant correlation between the yarn count and final twist.

The individual comparison of mean values presented in Table 2, regarding yarn lea strength for inter slub distance D_1, D_2 and D_3 show that the values have significant difference with respect to one another. The best value for yarn lea strength was obtained under D_3 (230mm) as 258.39 Pounds followed by D_2 (200mm) and D_1 (170mm) with their respective mean values as 255.04 and 250.81 pounds. These results get full support from the findings of Pouresfandiari (2003) who reported that the parameters influencing the characteristics and appearance of fancy yarns were the yarn count and the average distance between two consecutive effects.

Table 2. Comparison of individual mean values for yarn lea strength

Spinning System	Slub Length	Inter Slub Distance	Slub Thickness	Twist Multiplier
S_1=252.23 b	L_1=258.32	D_1=250.82	W_1=255.24	T_1=246.90 a
S_2=257.27 a	L_2=254.65	D_2=255.04	W_2=254.70	T_2=255.66 b
	L_3=251.28	D_3=258.39	W_3=254.31	T_3=261.69 c

Mean values having different letters differ significantly at 5% level of significance

at compact ring spinning machine (S_2), with lea strength 257.28 Pounds followed by conventional machine (S_1) as 252.23 pounds. Which endorse the views of Stalder (2000) who observed that compact yarns display significantly better strength and elongation values and also display better CV percentage . This leap in quality is so great that even with reduced twist, the condensed yarns displayed better values than normally twisted conventional yarns. Similarly, Ahmad (2004) investigated that in compact yarn less twist is possible without any loss of strength

The individual mean values of yarn lea strength for slub thickness W_1, W_2 and W_3 were obtained as 255.24, 254.69 and 254.31 lbs respectively, which have non-significant differences from one another.

The comparison of individual means concerning to yarn lea strength due to twist multiplier (T) presented in Table 2. The highest value of Yarn lea Strength 261.68 Pounds is recorded for T_3 (5.2) followed by 255.66 and 246.90 Pounds for T_2 (4.9) and T_1 (4.6) respectively. The results have significant difference with respect to one another. It indicates that as the twist multiplier

increases the value of lea strength also increased. These results were fully supported by Klein (1998) who stated that strength of a thread increased with increasing twist because of increased inter fibre friction with in the yarn. Selection of a twist level below maximum strength is appropriate because higher strengths were mostly unnecessary, cause the handle of the end-product to become too hard and reduce productivity. Similarly, Almashouley (1988) narrated that strength of cotton yarn varies with twist. Up to a certain point additional twist causes an increase in strength; however, beyond that point added twist causes a decrease in strength.

Yarn evenness (U %)

The statistical analysis of variance of yarn evenness indicates that the effect of spinning system (S), slub thickness (W) and twist multiplier (T) upon yarn evenness were highly significant. While non significant effects were also recorded for slub length (L), inter slub distance (D) and all possible remaining interactions. The Comparison of individual means of yarn evenness due to spinning systems S_1 and S_2 presented in Table 3 show that both these values differ significantly with

mm) as 16.53 percent followed by D_2 (200 mm) and D_3 (230 mm) with their mean values 16.50 and 16.49 percent respectively. Lord *et al.* (1998) reported that quality of a textile yarn is judged in the past by its evenness. The lack of evenness is caused by mechanical defects in the machine used to make the yarn.

The comparison of individual means concerning to yarn evenness percentage due to slub thickness is presented in Table 3. The values obtained of yarn evenness percentage were 16.37, 16.51 and 16.64 percent for slub thickness W_1 (1.6), W_2 (2.00) and W_3 (2.4) respectively. The results show significant difference from one another. These results were fully supported by Testore and Minero (1988) who reported that parameters influencing the characteristics and appearance of slub yarn were metric count, average number of slubs per meter, ratio of maximum to minimum diameter of yarn, average distance between consecutive slubs and slub length. Sheikh (1994) mentioned that yarn irregularity was a measure of cross-sectional variation in the yarn and closely associated with imperfections in the yarn. As regard to the twist multiplier results reveal that the highest value

Table 3. Comparison of individual mean values for yarn evenness (U %)

Spinning System	Slub Length	Inter Slub Distance	Slub Thickness	Twist Multiplier
S_1=16.66 a	L_1=16.48	D_1=16.53	W_1=16.37 c	T_1= 16.39 c
S_2=16.35 b	L_2=16.55	D_2=16.50	W_2=16.51 b	T_2= 16.50 b
	L_3=16.49	D_3=16.48	W_3=16.65 a	T_3= 16.63 a

each other. The highest value of yarn unevenness was obtained at conventional machine (S_1) as 16.66 percent followed by the modified machine (S_2) as 16.35 percent. These results were fully supported by Frey (2000) who stated that the compact yarn was found 15 to 20 percent higher in strength at 3 percent less twist and with 20 percent higher elongation, better U percentage and lower imperfection values. Similarly, Smekal (2001) stated that the technique improves the structure of the yarn, as the edge fibres are incorporated, leading to reduced hairiness, a higher yarn strength, and improved yarn evenness with fewer faults. The individual comparison of mean values, regarding yarn evenness for slub length (L) shows that the highest value of yarn unevenness was obtained at L_2 (60 mm) as 16.55 percent followed by L_3 (70 mm) and L_1 (50 mm) with their mean values 16.49 and 16.48 percent respectively and show non significant effect on yarn evenness. In case of inter slub distance the values show non significant difference from one another. The highest value was obtained at D_1 (170

of yarn unevenness 16.63 percent is recorded for T_3 (5.2) followed by 16.50 and 16.39 percent for T_2 (4.9) and T_1 (4.6) respectively, which shows significant effect on yarn evenness. Present results are in line with Sharma *et al.* (1987) who stated that strength parameters and elongation increases with twist level. The yarn unevenness increases with twist. Yonghua and Yan (1990) reported that there are many aspects of yarn quality, among them unevenness is very important because it is closely correlated with fabric appearance.

Weft wise tensile strength

The statistical analysis of data regarding weft wise tensile strength of fabric indicates that the effect of spinning system (S) and twist multipliers (T) is highly significant. While non-significant effects were recorded for slub length (L), inter slub distance (D), slub thickness (W) and all the remaining interactions.

The mean values of weft wise tensile strength of fabric for different spinning system S_1 and S_2 presented in

Table 4 show that both these values differ significantly from each other. The highest value of weft wise tensile the yarn count, lea strength, single end strength, fabric tensile and tear strength and fabric density. Most of the

Table 4. Comparison of individual mean values for weft wise tensile strength of fabric (lbs)

Spinning System	Slub Length	Inter Slub Distance	Slub Thickness	Twist Multiplier
S_1=133.58	L_1=135.17	D_1=134.87	W_1=135.18	T_1=131.20
S_2=136.45	L_2=134.99	D_2=135.18	W_2=135.09	T_2=135.33
	L_3=134.89	D_3=135.00	W_3=134.84	T_3=138.52

Mean values having different letters differ significantly at 5% level of significance

strength was obtained at modified compact spinning machine (S_2) as 136.45 lbs followed by conventional ring spinning machine (S_1) as 133.58 lbs. As the stronger yarn is produced on S_2 so its weft wise tensile strength is also high as compare to S_1. The results were fully correlated with Artz (1998) who stated that compact yarns always display higher yarn strength and elongation at a breaking length above the fibre staple length. A significant increase in fabric strength can be achieved only through a proportional increase in yarn strength. The product quality of the fabric in terms of strength is therefore, increased by using compact spinning.

The comparison of individual mean values relating to weft wise tensile strength of fabric at different levels of slub length (L) show that the difference in the mean values of slub length are non significant from one another. The maximum value is observed at slub length L_1 (50 mm) as 135.17 lbs followed by L_2 (60 mm) and L_3 (70 mm) with their respective mean values as 134.99 and 134.89 lbs. Therefore decrease of the weft wise tensile strength is found due to increase of slub length. As regard to inter slub distance results clarifying that the best value of fabric weft wise tensile strength is obtained for D_2 (200 mm) 135.18 lbs followed by 135.00 lbs and 134.81 lbs for D_3 (230 mm) and D_1 (170 mm) respectively. The results show non significant differences between these values. The comparison of individual means concerning to weft wise tensile strength due to slub thickness is represented by Table 4. The values obtained for slub thickness W_1, W_2 and W_3 are 135.18 lbs, 135.09 lbs and 134.84 lbs respectively which have non significant difference from one another.

The individual comparison of mean values for weft wise tensile strength under twist multiplier (T) shows that all these values were significant with one another. The best value is observed at T_3 (5.2) as 138.52 lbs followed by T_2 (4.9) and T_1 (4.6) with mean values 135.33 lbs and 131.20 lbs respectively. These results were consistent with the research work of Iqbal (2005) who concluded that twist multiplier significantly affected

tensile properties of the slub yarn and resultant fabric are improved by increasing twist multiplier. Yarn imperfections increase at higher slub length and population. However variation of thickness produced a non significant effect on most of the yarn and fabric properties. Likewise, Booth (1996) described that the variable that a technologist include in the tensile strength of the fabric are raw material characteristics, yarn structure (count, irregularity, twist factor, doubling etc) and fabric structure (settings, crimps percentage and weave). Whereas, Arora (2002) stated that high twist and high fibril cohesion increase the stability of spun yarn, giving longer yarn breakage time and twist increases the strength of the yarn by creating lateral forces which prevent the fibers in the yarn from slipping over one another also stated that under low stress the mechanical behavior of the fabrics is primarily determined by the structure and have significant effect on tensile behavior.

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