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Yarn Imperfections Under the Variant Polyester/Cotton Blend Ratios and Delivery Speeds of Vortex Spinning Machine

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Abstract. Murata vortex spinning (MVS) is relatively new technology and has gained value over ring and open end spinning in the last years due to its some remarkable advantages like producing yarn with low hairiness and pilling value and good color fastness and abrasion resistance. In this system of yarn manufacturing, the optimal settings of various processing and machine variables are of utmost importance in order to produce good quality yarn. Among all factors, raw material and yarn delivery speed play significant role. The present work endeavored to investigate the impact of various delivery speeds of MVS machine and polyester/cotton (P/C) blends upon the quality of yarn. In this regard seven different P/C blends and four variant delivery speed of the MVS machine were practiced and their impact on yarn imperfections were analyzed. The results sdisclosed very significant effects of all the selected variables on yarn imperfections.

Keywords: morata vortex spinning, machine variables, delivery speed, P/C blend ratios

Introduction

Murata vortex spinning is an advanced development of air jet spinning technology and has gained a popular and viable application in yarn manufacturing. This was first introduced at Osaka International Textile Machinery show in 1997 (OTEMAS' 97) in Japan by Murata Machinery Company, this relatively new technology has many advantages over rotor, air-jet and ring yarn spinning techniques in respect of removal of roving process, high speed and manufacturing of variety of yarn counts (Perez, 2017). The significance of MVS technology in respect of producing cotton yarn of having ring-like yarn properties with low hairiness and pilling tendency and producing resultant fabric with high abrasion resistance, greater humidity absorption and rapid drying properties has been recognized well by current version of air-jet spinning technology (Erdumlu and Ozipek, 2010; Ortlek *et al*., 2008).

In this technique four-roller apron drafting system is applied in order to give draft to feed drawn cotton sliver into desired yarn count. The fibres, so drafted, are taken by a nozzle in which exists high speed air vortex. The fibres get swirl under the action of this vortex around a hollow stationary spindle (Fig.1). These freely floating fibres twist around the bridge fibres and result in a ring-like yarn. The twist insertion takes place during the swirling of fibres around the apex of the spindle before they are being pulled down a shaft running through the middle of the spindle. The production capacity of MVS technique depends significantly upon its delivery speed along with the fact that the yarn manufacturing at this

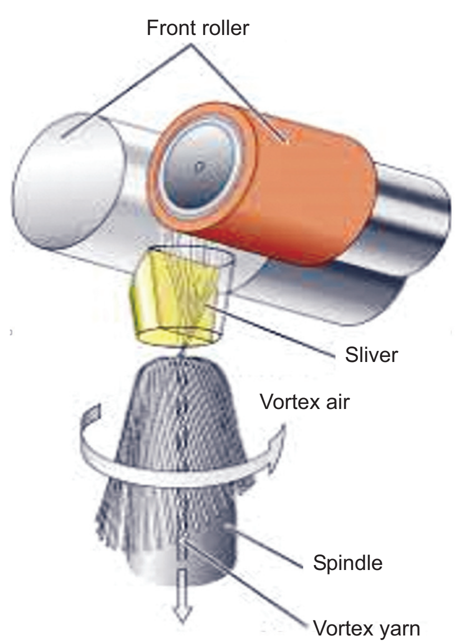

Fig. 1. Principle of murata vortex spinning (Tausif *et al*., 2018).

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system is directly from sliver, rather than roving (Kiron, 2013).

Much research work has been conducted on MVS technology with respect to various machine parameters. During his study (Tusief *et al*., 2012) observed profound impact of spindle dia and distance covered by P/C blended yarn from front roll to spindle on its tensile properties. Tyagi *et al*. (2005a andb) he reported that studied the low stress features of vortex yarn, woven fabric and thermal comfort under the influence of various spinning parameters. Similarly, the impacts of spindle diameter and its working time on viscose yarn produced by MVS technique were studied by (Ortlek *et al*., 2008).

However, the impact of the various delivery speeds on yarn imperfections in respect to different P/C blends has not been explored at this system that is being carried out in the present study. Furthermore, the other objective of this work was to have better understanding about the effect of different machine variables and inputs on the quality of the resultant yarn in order to optimize various machine settings and speeds to establish guide path for the manufacturers.

Experimental set up. This work was carried out in Fibre and Textile Technology Department of University of Agriculture Faisalabad, Pakistan and mainly conducted in Reliance Cotton Spinning Mills Ltd; Feroze Wattoan Sheikhupura, Pakistan. The experimental details regarding materials used and methods applied are given below.

Material used. Raw materials (polyester and cotton fibres) used in this research study was provided by the mill. The physical characteristics of the selected fibres were tested applying standard test methods, the details of which are:

Cotton fibre properties. Physical characteristics of cotton fibre were measured by high volume Instrument (HVI 900 A) M/S Uster Zellweger Ltd., Switzerland (1995). The testing was carried out following ASTM (American Society for Testing and Materials) standards, 2008. The measured properties of cotton fibres are given in Table 1.

Polyester fibre properties. Polyester fibre properties were considered as provided by the manufacturer, however for verification they were tested again using ASTM standards (ASTM, 2008a). The details for these measurements are given below and the properties of used polyester fibre are given in Table 2.

Table 1. Cotton fibre properties

Cotton fibre properties	Measured value
Length	28.21 mm
Strength	28.40 g/tex
Fineness	4.22 Mic
Uniformity ratio	49.54 %
Short fibre content	11.2 %

Table 2. Polyester fibre properties

Polyester fibre properties	Measured value
Length	38 mm
Fineness	1.28 denier
Tenacity	7 g/denier
Elongation	19 %

Denier. Denier is the fineness of the polyester fibre. It was measured by "Vibroscope" that measures the single fibre fineness automatically.

Tensile properties. The tensile related properties (tenacity and elongation) of polyester fibre were measured by Lenzing strength tester following the procedure laid down in its manual.

Staple length. As polyester fibres are stapled manually and all fibres have same length so the staple length of collected polyester fibres was determined by measuring the length of single fibre manually using measuring scale.

The measured values of polyester fibre are presented in Table 2.

Spinning process. Polyester and cotton fibres were blended according to the decided ratios as given in Table 3 at card section. After getting blended P/C sliver from card machine, it was processed further at draw frames for getting further homogeneity in blending. Then the blended P/C slivers were processed at Murata-vortex spinner (MVS-8R2) by changing the delivery speeds as given below (Table 3) in order to make 30sec count of the yarn.

For knowing the effect of blend ratios on the quality of resultant yarn, the delivery speed was kept constant at 320 m/min. Similarly for seeking the impact of delivery speed on yarn quality, the selected speeds were tested for 50:50 P/C blend ratio.

Other settings of machine adjusted were:

Table 3. The selected variables

Blend ratio (B) Polyester: Cotton (P/C)	Delivery speed
B_1= 80:20	S_1=300m/min
B_2= 70:30	S_2=320 m/min
B_3= 60:40	S_3=340 m/min
B_4= 50:50	S_4=360 m/min
B_5= 40:60	
B_6= 30:70	
B_7= 20:80	

Main draft ratio = 55; tension draft ratio = 170; nozzle pressure = 0.45 m bar; condenser (gray) = 3 mm; The atmospheric conditions of the section were dry temperature = 34 °C; wet temperature = 26.5 °C and relative humidity = 52 %

Measurement of yarn imperfections. The imperfections in yarn like yarn unevenness, thin places per kilometer, thick places/kilometer and neps/kilometer were measured by Uster Evenness tester-3 (UT-3) following the working procedure as mentioned in its operating manual using standard ASTM method (ASTM, 2008a). The sensitivity of testing for the thin places was at –50% and for thick places as +50% and that for neps +200%.

Data analysis. The collected data was analyzed statistically applying DMR (Duncan Multiple Range) test as suggested by Montogomery (2009) using SPSS (Statistical Package for Social Sciences) software.

Results and Discussion

The results pertaining to the present research project are presented and discussed along with their statistical manipulation here under

Yarn unevenness (U %). The results regarding yarn un-evenness under the selected variables are presented in Table 4. The data very clearly discloses highly significant impacts of P/C blend ratios (B) and delivery speed (S) on the evenness of yarn. It is very clear from the data that with the increasing ratio of polyester in the blend the yarn evenness improved (Fig. 2). This can be attributed to the fact that polyester fibres have higher mean length as compared to that of the cotton fibres (Vadicherla and Saravanan, 2017)

The mean values of yarn unevenness with respect of variant delivery speeds sec as represented in Table 4 are 11.29, 11.00, 10.74 and 11.35 (U-percent) for S_1, S_2, S_3 and S_4 respectively. It is clear from the data that the high delivery speed showed an initial decrease and then increase in yarn un-evenness (Fig.2). This can be credited to the point that the increasing tangential velocity favors the twisting of open trail end fibes. On the other hand, decreasing this velocity results in weakening this twisting effect that ultimately put significant impacts on yarn evenness (Tripathi *et al*., 2021).

Table 4. Comparative analysis of mean values for yarn un-evenness (U%)

Blend ratio (B)	Delivery speed (sec)
B_1 = 10.43^g	S_1 = 11.29^b
B_2 = 10.62^f	S_2 = 11.00^c
B_3 = 10.83^e	S_3 = 10.74^d
B_4 = 11.00^d	S_4 = 11.35^a
B_5 = 11.24^c	
B_6 = 11.41^b	
B_7 = 11.91^a	

The values having different letters differ each other significantly at 0.05 probability level

Fig. 2. Yarn un-evenness under the influence of various blend ratios and delivery speeds.

Yarn thick places/ Km. The comparison of mean values regarding yarn thick places per kilometer for different P/C blend ratios and delivery speeds is displayed in Table 5. It can be interpreted from the data that the number of yarn thick places increased with decreasing ratio of polyester in the blend. This can be attributed to the shorter mean length of cotton fibres as compared to that of the polyester fibres in the blend. Moreover, the linear density of cotton fibre is lower than that of polyester fibre which significantly impact the number

Table 5. Comparative analysis of mean values for yarn thick places/Km

Blend ratio (B)	Delivery speed (sec)
$B_1 = 232.86^g$	$S_1 = 287.97^d$
$B_2 = 257.69^f$	$S_2 = 306.89^c$
$B_3 = 279.67^e$	$S_3 = 325.25^b$
$B_4 = 312.89^d$	$S_4 = 342.87^a$
$B_5 = 338.33^c$	
$B_6 = 379.97^b$	
$B_7 = 408.81^a$	

The values having different letters differ each other significantly at 0.05 probability level

Table 6. Comparative analysis of mean values for yarn thin places/Km

Blend ratio (B)	Delivery speed (sec)
$B_1 = 36.3^g$	$S_1 = 35.14^d$
$B_2 = 38.4^f$	$S_2 = 41.19^c$
$B_3 = 40.6^e$	$S_3 = 44.79^b$
$B_4 = 42.3^d$	$S_4 = 48.12^a$
$B_5 = 43.6^c$	
$B_6 = 46.6^b$	
$B_7 = 48.5^a$	

The values having different letters differ each other significantly at 0.05 probability level

of thick places in the resultant yarn (Vadicherla and Saravanan, 2017).

Similarly the mean values of yarn thick places for S_1, S_2, S_3 and S_4 which are 287.97, 306.89, 325.25 and 342.87/Km respectively as shown in Table 5. The range of yarn thick places for different delivery speed is recorded from 287.97 to 325.25. The data clearly defines that delivery speed directly influence the yarn thick places. As it increased, the thick places in the resultant yarn increased (Fig. 3). These results are closely related to the observation of Bhortakke *et al*. (1997) who reported that increased delivery speed put inclusive impact on yarn neps and thick places.

Yarn thin places/Km. The data regarding the yarn thin places per kilometer for selected variables is presented in Table 6. The results very clearly revealed the significant impacts of both P/C blend ratios and delivery speed on yarn thin places. It can be depicted from the data that the increasing ratio of polyester in the blend play significant role to reduce the thin places. These findings are in line with the results concluded by (Shehzad, 2003) that the increasing share of polyester in the blend decreased the imperfection level of the yarn.

Statistical comparison of mean values regarding yarn thin places at different delivery speeds (Table 6) obviously defines that lower spinning speed gave small number of thin places (Fig. 4). These results are closely related to the observation of Lawarance and Baqui (1991) who narrated that the increased the production speed gave significant increase in number of thin places

Yarn neps/Km. The data regarding yarn neps/Km is represented in Table 7. It is clear from the results that both blend ratios and delivery speeds put significant effects on yarn neps count. The range of yarn neps for different P/C blends is recorded from 250.83 to 494.30.

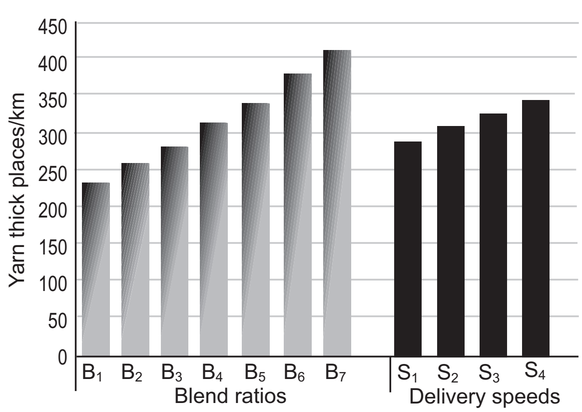

Fig. 3. Yarn thick places/Km under the influence of various blend ratios and delivery speeds.

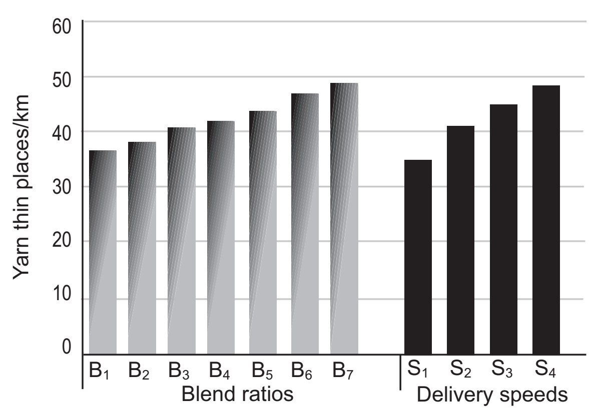

Fig. 4. Yarn thin places/Km under the influence of various blend ratios and delivery speeds.

Table 7. Comparative analysis of mean values for yarn neps/Km

Blend ratio (B)	Delivery speed (sec)
B_1 = 250.83[g]	S_1 = 372.38[a]
B_2 = 285.83[f]	S_2 = 364.12[b]
B_3 = 310.91[e]	S_3 = 361.00[c]
B_4 = 353.72[d]	S_4 = 356.86[d]
B_5 = 403.64[c]	
B_6 = 445.89[b]	
B_7 = 494.30[a]	

The values having different letters differ each other significantly at 0.05 probability level.

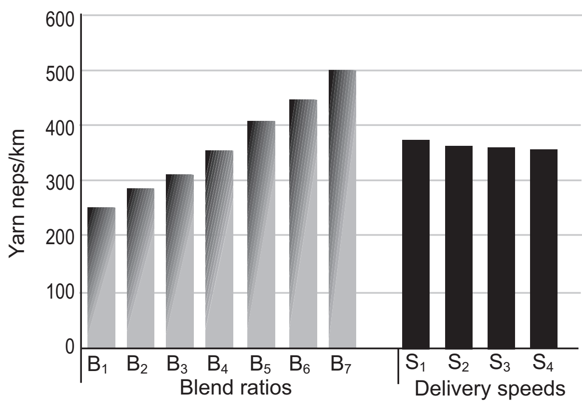

Fig. 5. Yarn neps/Km under the influence of various blend ratios and delivery speeds.

The observed figure depict that the percentage of polyester and yarn nep count were found inversely related. This is because of the increase length of polyester fibres because of which their linear density is higher than that of cotton. This is the main factor that put positive effect on the reduction of neps/Km in the yarn with high ratio of polyester (Vadicherla and Saravanan, 2017).

The comparative analysis of yarn nep count for variant delivery speeds (Table 7) indicates that that as the delivery speed increased the yarn neps value decreased (Fig. 5). These findings are endorsed by Ortlek and Ulku (2005) who noted that increasing the delivery speed increased the hairiness and decreased the number of neps of vortex yarns.

Conclusion

On the basis of the present investigations and collecting data it is concluded that the higher percentage of polyester in the polyester/cotton blend improved the overall quality of the resultant yarn spun at vortex spinning system. The focus was carried out on yarn imperfections and the results very clearly defined good quality resultant yarn in respect of yarn evenness and imperfection level. The second parameter selected for the current study was related to machine delivery speed that also put significant impacts on yarn quality. The increase in speed resulted in increase of yarn imperfection level. This is because the change in speed directly affected the linear density of the yarn that resulted in the twist variation received by the yarn. Ultimately the imperfection level of the resultant yarn disrupted.

Conflict of Interest. The authors declare that they have no conflict of interest.

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