THE APPARENT LOSS OF TWIST IN OPEN-END COTTON/POLYESTER BLENDED YARNS.

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ABSTRACT The phenomenon of twist loss in open-end staple spun yarns has been explained by the slippage between Fiber ring and rotor wall and the reaction to wounding moment during twist insertion. In the present study some variables such as: blend composition, twist multiplier, yarn count, staple length and fineness of fibers were chosen to explore the twist efficiency of rotor cotton/polyester blended yarns. The experiments were carried out by varying two variables at different levels and three variables factorial design technique. The results declared that twist efficiency was found to be influenced significantly by O.E C/P yarn parameters. In addition to the above parameters, the two factor interaction such as blend composition with twist multiplier and blend composition with yarn count affect significantly the twist efficiency. Also, it has been shown that there is a strong correlation between twist loss and fiber blend parameters.

1. INTRODUCTION:

In rotor spinning m/c, the loss in twist inserted in the yarn has been variably attributed to:
- The unique core-sheath bipartite structure of the rotor yarns.
- The leakage of twist through the tail of the fiber band and,
- The slippage between the fiber and the rotor wall.

From the work of other research workers, we can draw some information on the twist efficiency and an explanation for the phenomenon of twist loss in terms of the following parameters:

(i) Open-end yarn formation: in one such study (1) it was stated that some fibers slip particularly the surface fibers as they leave the collecting surface resulting in twist loss. It was thought that the core fibers do not slip much. Sultan and

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(ii) Effect of some open-end m/c parameters, such as rotor type, extractive nozzle and combing roller speed. It has been shown that the use of grooved drafting tube increases the wrapper fibers due to an increased false twist action resulting in an elongated peripheral twist extent (3). Also, it has been stated (4) that the use of grooved drafting tube results in a decreased twist efficiency. Manich et al. (5) studied the effect of extractive nozzle and rotor type as a qualitative factor on the apparent loss of twist in open-end spun yarns. Both rotor and nozzle type exert a significant influence on residual twist, which tends to increase when the nozzle produces a rising false twist effect and to diminish when friction of the yarn against rotor increases. The effect of combing roller speed on twist efficiency and the percentage of sheath fibers has been studied (6). As the combing roller speed increases, there is a gradual reduction in the percentage of sheath fibers, i.e., the possibility of some fibers becoming wrapper fibers. Also, they result in the twist efficiency going up as the combing roller speed is increased.

(iii) Effect of fiber and yarn parameters:
In relation to the type of fiber, it has been shown that, compared to cotton fibers, the viscose rayon staple fibers show a highly percentage of sheath (7) and a lower twist efficiency (8). Viscose rayon fibers of different lengths with the same linear density affect significantly on twist efficiency. Tyson (9) who also agreed that there is twist loss attributed this to the torsional rigidity of the fibers in the untwisted ribbon resulting in a reaction to the turning moment which inhibits the process of twisting from being 100% efficient. In relation to O.E. yarn parameters, a decrease in twist multiplier leads to a reduction in the sheath fibers and an increase in the twist efficiency (6). Also, residual twist increases significantly in a linear manner with yarn linear density.

Thus, the present work tends to study the influence of some variables on the apparent loss of twist in open-end C/P blended yarns. The experiments carried out to investigate the following:

- The effect of blend composition, twist multiplier and yarn count on twist loss.
- Statistical analysis were made on the three variables factorials on the basis of three level for each.
- The effect of the type of fiber component, Mean fiber length in blends, and fiber fineness as a function of no of fibers/ cross-section on twist efficiency.

2. EXPERIMENTAL WORK:

2.1 Material Used:
Misr polyester staple fiber of 38 mm effective length, 1.4 denier and 5.9 gram/denier, and Egyptian cotton fibers "Giza 75" with staple length 28 mm, 4.5 µg/in and pressley index = 9.8 were used in the present study.

2.2 Open-End C/P blended yarn production:
The machine sequence was adapted for the individual components and blends. Separate lines for polyester and cotton were used for opening, cleaning and carding. The two components were blended at drawing frame and blend levels were achieved by varying the relative number of cotton and polyester sliver fed on the drawing frame.

The blended slivers were fed to rotor spinning using opening roller 63 mm in diameter, its speed was 7300 t. min⁻¹ and 8900 t. min⁻¹, while the rotor diameter 45 mm and worked at constant speed 45000 t. min⁻¹.

Three spinning variables : twist multiplier, yarn count and blend composition.
were changed while the other machine parameters were kept constant as shown in table (1).

### Table (1)

<table>
<thead>
<tr>
<th>Yarn Count</th>
<th>Twist Multiplier (x)</th>
<th>Cotton/Polyester Blend Level</th>
<th>Designation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100 %</td>
<td>25 %</td>
<td>50 %</td>
</tr>
<tr>
<td>3.6</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>4.0</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>6.7</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>5.5</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>5.8</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

C : Cotton fibers (Giza 70) ; P : polyester staple fibers
C<sub>1</sub> : Yarn count "for yarn linear density" ; i = 1, 2, 3
C<sub>1</sub> = 18 Ne (33 tex) ; C<sub>2</sub> = 22 Ne (27 tex) and C<sub>3</sub> = 28 Ne (21 tex)

2.3 Measurements:

The apparent loss of twist was determined by means of the untwist-twist method. This method works through medium of twist contraction; sufficient reverse twist is inserted to restore the original length under a stated tension and it is assumed that one half the algebraic difference in twist is the amount originally contained in the sample. The difference between machine twist and yarn twist is known as apparent loss of twist and expressed as a percentage

\[
T_r = \frac{(T_m - T_y)}{T_m} \times 100
\]

where \(T_r\) : residual twist or the apparent loss of twist, \(T_m\) : machine twist and \(T_y\) : yarn twist.

While the ratio between yarn twist and machine twist is known as twist efficiency (\(\eta\)).

In addition, yarns were examined for yarn count on Autosorter, yarn strength on Tensomat strength tester and irregularity on Uster evenness tester.

2.4 Statistical Analysis:

The experimental design technique factorial design applied for the apparent loss of twist in open-end c/p blended yarns, as shown in table (2), to examine the main effect of three variables:

- **Twist multiplier**: (-1) 3.6<sub>C</sub>, (0) 4.7<sub>C</sub>, (+1) 5.3<sub>C</sub>
- **Yarn count**: (-1) 18<sub>N</sub>, (0) 22<sub>N</sub>, (+1) 28<sub>N</sub>
- **Blend composition**: (-1) 100<sub>c</sub>, (0) 50<sub>c</sub>/50<sub>p</sub>, (+1) 100<sub>p</sub>

Also, it was decided to investigate all combinations of three levels of each of three variables.
Table (2). Values of Residual twist ($T_e \%$)

<table>
<thead>
<tr>
<th>Level of O. E yarn Count ($C_1$)</th>
<th>$C_2$</th>
<th>$C_3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level of blend ratio ($B_1$)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$B_1$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$B_2$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$B_3$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level of blend ratio ($B_1$)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$B_1$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$B_2$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$B_3$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level of blend ratio ($B_1$)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$B_1$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$B_2$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$B_3$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\alpha_1$</td>
<td>$T_{r1}$</td>
<td>$T_{r2}$</td>
</tr>
<tr>
<td>$\alpha_2$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\alpha_3$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. Results and Discussions:

3.1 Effect of twist multiplier, yarn count and blend composition on twist loss.

Fig. (1) shows the effect of twist multiplier on twist loss in c/p blended yarns. It is seen that, as the twist increased from $\alpha_e$ 3.6 to $\alpha_e$ 5.8 there is almost a continuous increase in residual twist ($T_e \%$), i.e., the twisting efficiency decreases. This trend has been observed for all yarns.

The experimental results, are given in figures (2) and (1), indicate that the influence of yarn count "or Linear density" on O.E yarn residual twist, it is clear that, residual twist decreases Linearly when yarn Linear density decreases from 33 tex to 21 tex. The variation is very closer in case of cotton yarn while a substatial differences exist in case of blends and 100% polyester yarns.

The curves, as shown in Figures (3) and (4), explore the relationship between fiber blend composition and twist loss in rotor spinning yarns. It is seen that, the higher polyester content in blend, the lower twist efficiency. While a higher twist efficiency has been found for 100% cotton yarn.

Statistical analysis of results are shown in tables (3) and (4) in terms of the main effects and two-factor interactions. It can be noticed that from the variance analysis, the Linear main effect of blend composition is highly significant at the level 1%. Also, the Linear and quadratic effect of yarn count are statistically significant at 1% and 3% respectively. In the same time the Linear effect of twist multiplier is significant at 5%.

The two-way table (5) indicate the interaction between two parameters. From the blend composition with yarn count ($B \times C$) interaction, it is seen that a higher rate of twist loss at both higher percentage of polyester in blends and coarse yarn count, while a lower rate has been observed for lower yarn linear density and 100% cotton yarns. The linear effect of ($B \times C$) is significant at 1% level and ($B \times C$) is significant at 1% level. The linear effect of blend composition with quadratic effect of yarn count ($C^2$) affect significantly on the apparent loss of twist in open End blended yarns at 95% level.

From the two-way table ($\alpha_e \times B$); the blend composition ($B$) has the same trend whatever the condition of other factors" twist multiplier and yarn linear density (tex). The Linear effect of ($\alpha_e \times B$) is significant at 10% level. Also, a rise of twist loss has been observed at twist multiplier changes from $\alpha_e$ 3.6 to 5.8 for blend (50/50 c,p) comparing to 100% open-end cotton-spun yarns.
### Table (4) The Two-way tables

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Mean Squares (ms)</th>
<th>Variance Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) Main Effect :</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blend Composition</td>
<td>$1413.41$</td>
<td>$1028.70$ $^6$</td>
</tr>
<tr>
<td>Yarn Count</td>
<td>$19.20$</td>
<td>$1.35$</td>
</tr>
<tr>
<td>Twist multiplier</td>
<td>$213.35$</td>
<td>$151.54$ $^6$</td>
</tr>
<tr>
<td>Q</td>
<td>$199.67$</td>
<td>$10.89$ **</td>
</tr>
<tr>
<td>Q</td>
<td>$88.88$</td>
<td>$6.47$ **</td>
</tr>
<tr>
<td>Q</td>
<td>$1.19$</td>
<td>$0.09$</td>
</tr>
<tr>
<td>(ii) Two-Factor Interactions :</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blend composition and yarn count</td>
<td>$870.40$</td>
<td>$63.35$ $^5$</td>
</tr>
<tr>
<td>(B L x C L)</td>
<td>$1.60$</td>
<td>$0.12$</td>
</tr>
<tr>
<td>(B Q x C L)</td>
<td>$121.73$</td>
<td>$8.86$ **</td>
</tr>
<tr>
<td>(B L x C Q)</td>
<td>$10.21$</td>
<td>$0.74$</td>
</tr>
<tr>
<td>Twist factor and blend composition</td>
<td>$64.37$</td>
<td>$4.72$ *</td>
</tr>
<tr>
<td>(L x Q x B L)</td>
<td>$6.17$</td>
<td>$0.45$</td>
</tr>
<tr>
<td>(L x Q x B Q)</td>
<td>$18.33$</td>
<td>$1.29$</td>
</tr>
<tr>
<td>Twist factor and yarn count</td>
<td>$14.59$</td>
<td>$1.06$</td>
</tr>
<tr>
<td>(L x Q x C L)</td>
<td>$7.21$</td>
<td>$0.51$</td>
</tr>
<tr>
<td>(L x Q x C Q)</td>
<td>$9.71$</td>
<td>$0.71$</td>
</tr>
<tr>
<td>(L x C Q)</td>
<td>$0.51$</td>
<td>$0.04$</td>
</tr>
<tr>
<td>(L x Q x C Q)</td>
<td>$8.39$</td>
<td>$0.61$</td>
</tr>
</tbody>
</table>

- Significant levels: ($^6$) at 1%, ($^5$) at 5% and ($^2$) at 10%
- L: is the linear effect and Q : is the quadratic effect of the variables

While the change in twist factor (for 100% polyester yarns) shows a slight variation in twist loss.

From the two-way table (L x C) there is a noticeable decrease in twist loss to changes in the level of yarn count. The best results obtained at low twist multiplier and lower yarn linear density.
It is clear from the above results, the coarser the yarn or the higher the twist or the higher the percentage polyester in the blend the higher apparent loss of twist. This may be explained by fiber slippage during yarn formation within the rotor. These parameters causing an increase in the amount of fiber slippage and consequently increases the radial twist gradient which represented by the difference between the surface twist and machine twist[10].

3.2 Effect of staple length and fineness of C/P fiber blends on the apparent loss of twist:

In terms of the type of fiber blend components, it has been shown that, compared to cotton fibers, the Open-end yarns produced from 100% polyester fibers and C/P blends show a higher apparent loss of twist (Tr %), as explained in the earlier section.

In the present investigation, yarns spun from cotton/polyester blends has five different length. The experimental results indicate that the fiber length affect significantly on twist efficiency as shown in Figs. (6) and (7). As the staple length increased it caused a drop in the twist efficiency. This may be explained by the increase in fiber length causing an increase in the sheath fibers and consequently affect on twist level[6].

The statistical results shows a strong relationship between the fiber length and twist efficiency. The values of correlation coefficient between the two are very high ranging between \( r = -0.823 \) and \(-0.958\) for yarn count Ne 18 and Ne 28 respectively.

In terms of fiber fineness, the relationship between twist loss and number of fibers/cross-section is plotted graphically as shown in Fig. (2) for different blend composition. A substantial reduction in twist loss with increasing number of fiber/ cross section and varying cotton/polyester blend level. The effect is particularly prominent for 50c/50p, 33c/65p and 100% polyester yarns, while a slight variation occurred for 25p/75c and 100% cotton yarns. Statistically, the correlation coefficient \( r^2 \) between twist efficiency and the no of fiber/cross-section is (-0.588) for 100% cotton, (-0.839) for 50c/50p, and (-0.94) for 100% polyester yarns.

The combined effect of fiber length in blends (Lb), number of fibers/cross section (nF) and fiber coefficient of friction (\( \mu \)) expressed by the term \( S = L_b \cdot n_F \cdot \mu \) and plotted against twist efficiency as shown in Fig (9). Within the range studied for each variables, increase of \( (L_b, n_F, \mu) \) leads to a reduction in twist efficiency \( (r = -0.97) \).

It is clear that from the above discussion, the fiber length, coefficient of friction and fineness play a significant part in determining the apparent loss of twist. This proof the hypothesis given by lord and Grady[20]. They have investigated the twist structure of Open-End yarns as follows:

\[
\tan \psi = \Delta T \cdot / (l_w + n_F) \cdot r = 2\pi r C 
\]  

where \( C \) is the twist/inch and \( r \) is the radius in inch the equation suggests that the twist structure wile be determined by: fiber denter (which will affect \( l_w \)) the forces developed in yarn formation zone, finish (which will affect \( n_F \)) coefficient of friction between the fiber and surface over which it is being dragged, rotor speed and size (which will affect the centrifugal force \( n_F \) acting on those parts of the fiber in contact with the surface), yarn count (which will affect \( r \) yarn radius) and false twist level which will affect \( \Delta T \) torque reaction.
4. CONCLUSIONS:

The present study permits the following conclusions to be drawn:

i) The results indicate that, the Open-end yarn parameters: blend composition, twist multiplier and yarn linear density affect significantly the apparent loss of twist as follows:-

i) An increase in the polyester percentage in blends leads to a decrease in the twist efficiency and there is a slight change in twist loss associated with 100% cotton and cotton/polyester blended yarns containing higher %age of cotton fibers.

ii) A decrease in the twist multiplier resulted in an increase in the twist efficiency.

iii) Residual twist influences significantly as linear density of yarn (tex.) changes. The apparent loss of twist increases as yarn linear density increases.

2. The application of experimental design technique (3) clearly shows the following:

i) The linear effect of the three variables on twist loss is highly significant, at 1% level for blend composition and yarn count, while at 5% level for twist multiplier.

ii) The two-factor interaction such as (BxG) : blend composition with yarn count; and (BxExG) : blend composition with twist multiplier affect significantly the apparent loss of twist.

3. The variation between machine twist and yarn twist, which is known as apparent loss of twist, resulted in more fiber entanglement in the strand during yarn formation and provide a higher strength.

4. The existing correlation between the apparent loss of twist and fiber blend parameters is highly significant and increases:

- As the Mean fiber length in blend increases (r varies between - 0.83 and - 0.94)
- When the number of fibers/cross-section increases. The influence is particularly prominent for 100% polyester (r = - 0.94) while a little change obtained for 100% cotton yarns (r = - 0.83).
- Also, the combined effect of mean fiber length, number of fibers/cross-section and fiber friction coefficient : \( L_b \times N_c \times \mu \) on twist loss is highly significant (r = - 0.963).

REFERENCES:

Fig. (1) Effect of Twist Multiplier on The Apparent loss of Twist ($T_p$) in Open-End Cotton/polyester Blended Yarns.

- (x) 19Tw : (x) 22Tw : (x) 26Tw
Fig. (2) Effect of Yarn Linear Density on The Apparent Loss of Twist in O.E Yarn

Fig. (3) Relationship Between Twist Efficiency \( (\eta) \) and Blend Composition

Fig. (4) Effect of Blend Composition on The Apparent Loss of Twist in O.E Yarns.
Fig. (6) Correlation Coefficient (r) Between Twist Efficiency (γ) and Fiber Length in Cotton/Polyester Blends.

Fig. (7) Relationship Between Twist Efficiency (γ) and Mean Fiber Length in Cotton/Polyester Blends at Various Twist Factors.
Fig. (8) Relationship between Twist Efficiency (T) and No. of Fibers/Cross Section at various blend levels.

Fig. (9) The combined effect of Mean Fiber Length and No. of Fibers/Cross Section on Twist Efficiency in O.E blended yarns.