BLENDING BEHAVIOR OF COTTON AND POLYESTER FIBERS ON DIFFERENT SPINNING SYSTEMS IN RELATION TO PHYSICAL PROPERTIES OF BLENDED YARNS

Ghada Ali Abou-Nassif

Fashion Design Department, Design and Art Faculty, King Abdul Aziz University, Jeddah, Saudi Arabia.

Corresponding author: Ghada Ali Abou-Nassif
E-mail: drghada2017@gmail.com

Abstract

Blending of natural and synthetic fibers has gained a large popularity in the last few years.
One of the most popular types of blending in the textile sector is cotton and polyester fibers because the wonderful aesthetic and functional properties which can be obtained for the products made from them. In this study, properties of cotton: polyester blended yarns spun from two spinning techniques, i.e. compact and ring spinning methods were compared. The influences of the polyester ratio on the functional and aesthetic properties of the produced yarns were also investigated. The impact of the independent variables on the characteristics of the blended yarns at 0.01 significant level were detected using Two-way analysis of variance .A regression models which correlate polyester ratios and blended yarn properties were also derived. The findings of this study revealed that polyester ratio has a significant influence on compact and ring cotton:polyester blended yarns. Most properties especially tensile ones have been enhanced significantly by increasing the polyester ratio. Compact blended yarns exhibited enhanced and higher properties compared to their counterparts spun on ring spinning technique.

Introduction

Cotton and polyester fibers are considered the most important textile fibers worldwide. They are mostly used for home, furnishing and apparel purposes. Cotton is preferred due to its comfort properties; while polyester has high strength properties. In order to enhance the functional and aesthetic properties of the textile products, cotton fibers are blended with different man made fibers, especially polyester is the most preferred one [1, 2].

Many researchers have studied the properties that can be obtained from blending of different textile fibers. It was stated that uniformity, technical and engineering, functional and aesthetic properties are attributable to blending textile fibers [3, 4]. Reduction of the production cost was also considered one of the most important reasons for blending [5].

Numerous of the effects of fiber blending on spinning and weaving performance were also detected [6]. A higher number of yarn breaks during its processing leads to a higher machine stops and consequently lowers the machine efficiency. It was found that weaving performance of blended yarns was better than 100% cotton yarns. This is because the fact that the strength properties of blended yarns are superior to those made from 100% cotton fibers [7].

Generally, many researches [8-11] have been conducted on the influence of blending different textile fibers whether these fibers originate from natural or synthetic sources on yarn characteristics and the properties of fabrics woven from these blended yarns. It was concluded that blending significantly enhanced yarn and fabric functional and aesthetic properties. Enhanced fabric appearance by reducing pilling attitude was achieved by blending of polyester and natural fibers. It was also found that blending of cotton and viscose fibers enhanced significantly the comfort of fabrics produced from them.

Blending of textile fibers can be performed in the blow room or on the drawn slivers. These slivers can be processed on ring spinning, compact, open-end spinning machines,--etc. Compact spun yarns have superior properties compared to their counterparts spun on open end and ring spinning systems with respect to higher tensile properties and lower hairiness index [12-15].

This paper sheds light upon the behavior blending of cotton with polyester fibers. The blended yarns were spun on different two spinning techniques, namely compact and ring spinning systems. The effects of polyester ratio and spinning type on the functional and aesthetic properties of the produced blended yarns were compared and investigated extensively.

Materials

In this study, eight yarn samples were spun and produced. Four yarn samples from blending of cotton and polyester fibers were spun on compact spinning machine of model Rieter-K44 with different four polyester ratios, i.e. 0%, 35%, 70% and 100%. Blended yarn of 0% and 100% polyester ratios means these yarns were spun completely from cotton and polyester fibers respectively. The second half of the yarns under study were spun on ring spinning machine of type Platt Saco Lowell with the same four polyester ratios.

The compact and ring spinning machines were kept at the same parameter as follows:

- Drafting gauge = 1.14 mm
- Spindle speed = 1300 rpm.
- Traveller count = 40
- Delivery speed = 7 m/min.
- Sliver count = 3280 Tex
- Roving count = 211 tex (2.8 Ne)
- Net yarn count = 30 Ne (19.7 tex)

Laboratory testing

Before testing, the spun yarns were kept for one day in a standard atmosphere, i.e. 20oC±2 temperature and 65% ±2 relative humidity. Each yarn was tested fifty times for each property and the average of all measurements were calculated.

Yarn tensile properties were measured on Uster Tensorapid measuring instrument according to ASTM Standard D2256. Yarn unevenness and hairiness were measured on Uster Tester 4 in accordance with ASTM D1425. In this study, yarn hairiness was characterized by hairiness index which is the total of hair length protruding from 1 cm of the yarn surface divide by l cm of the yarn length.

Statistical analysis

In order to detect the effects of polyester ratios and the type of spinning techniques of the properties of the cotton/polyester blended yarns, 4×2 analysis of variance was executed. The significance effect of each variable on each yarn property was detected at 0.01 significance level. To derive regression models which correlate polyester ratio with each yarn property, regression analysis was also performed. Each regression model was validated using calculating the coefficient of correlation between dependent and independent variable.

Results and discussion

Tensile strength

Enhancing the breaking force of the blended yarns is considered one of the most important parameter which is intended by the blending process. The influence of polyester ratio on the tensile strength cotton/spandex blended yarns was depicted in figure 1. It was noticed that polyester ratio and the type of spinning system have a huge influence on the tensile strength of spun yarns. As the polyester ratio increases the yarn tensile strength also increases. It was calculated that the tensile force of compact and ring yarns spun from cotton/polyester blended fibers have increased by 40% and 47% respectively by increasing the polyester ratios. It was also found that the effect of polyester ratio accounted for 85 % of the effects on yarn tensile strength while spinning technique accounted for about 14%. It was also noticed that irrespective the type of spinning system, cotton/polyester compact spun yarn has a higher tensile strength than their counterparts made from ring yarns by approximately 11.8%. This is because the higher bending of fibers in cross-section of the spun yarns accompanied with compact spinning.

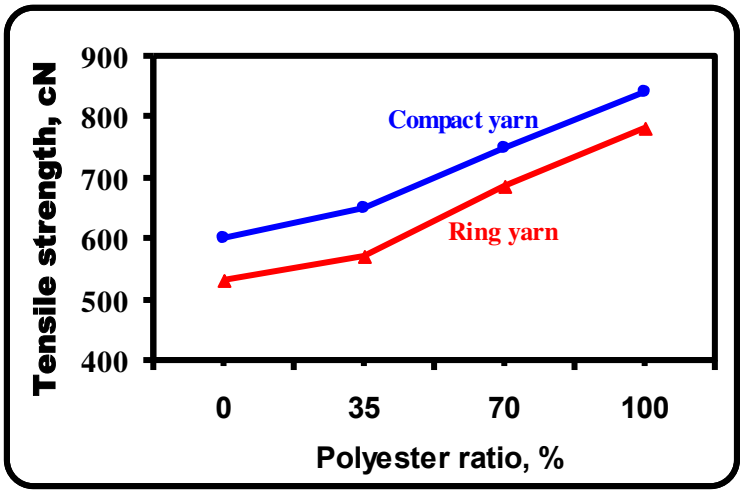

Fig.1: Tensile strength versus polyester ratios for compact and ring cotton/ polyester blended yarns.

The regression models which correlate percentage of polyester with tensile strength of cotton/ polyester ring and compact spun yarns have the following linear forms;

Breaking force, cN (compact yarn) = 58 × polyester ratio +532
Breaking force, cN (ring yarn) = 61.5 × polyester ratio +450.5

The correlation coefficients of these models were found to equal 0.975 and 0.96 for compact and ring spun yarns respectively. This means that polyester ratio has a positive and strong correlation with tensile strength of blended yarns.

Breaking elongation

Breaking elongation of spun yarns determines the elasticity and extensibility of fabrics woven from these yarns. Breaking elongation of cotton/polyester compact and ring spun yarns against the percentage of polyester fibers was illustrated in figure 2. It was proved that polyester ratios and spinning method have a profound impact on the elongation at break for these types of blended yarns. It is found that polyester ratio and spinning type accounted for 85% and 15% respectively of the effects on yarn breaking elongation. It can be seen from this figure that the higher polyester ratio is, the higher breaking strength of the produced spun yarns under study. As the polyester ratio increase the breaking strength of cotton:polyester compact and ring spun yarns by approximately 35% and 37% respectively. Irrespective the polyester ratio, cotton/polyester compact spun yarns exhibited higher elongation than ring spun yarn due to the higher binding and incorporation of fiber in the yarn structure.

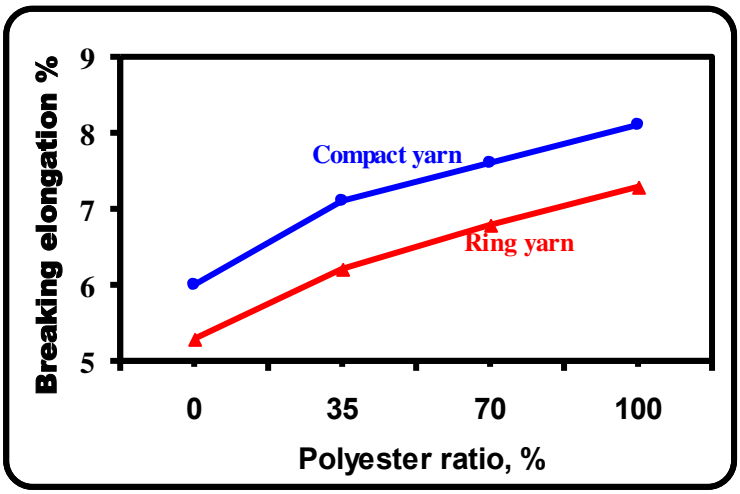

Fig.2: Breaking elongation versus polyester ratios for compact and ring cotton/ polyester blended yarns.

The regression models which correlate polyester ratios with breaking elongation of cotton / polyester compact and ring pun yarns have the following linear forms:

Breaking elongation, % (compact yarn) = 0.68 × polyester ratio +5.5
Breaking elongation, % (ring yarn) = 0.66 × polyester ratio +4.75

The correlation coefficients of these models were found to equal 0.955 and 0.81 for compact and ring spun yarns respectively. This means that polyester ratio has a positive and strong correlation with breaking elongation of blended yarns.

Breaking work

Breaking work (Work of rupture) is the area under the load elongation curve of the spun yarn. Thus it can be anticipated that the effect of independent variables in this study on the work of rupture of spun yarns will behave the same as their effects on breaking force and breaking elongation. The variation of work of rupture of cotton:polyster compact and ring spun yarns at different levels of the polyester percentage was depicted in figure3. The statistical analysis revealed that variables, i.e polyester ratios and spinning technique have a significant impact on yarn work of rupture. It was estimated that the effect of polyester ratios and the type of spinning accounted for 78% and 21% of the effects on breaking work of cotton/polyester compact and ring spun yarns respectively. From figure 3, as expected, the higher polyester ratio is, the higher breaking work of both types of yarns. Increasing polyester ratio leads to an increase in the breaking ratio of cotton :

polyester from 600 to 2200 gf.cm for compact spun yarn , and from 520 to 1950 gf.cm for ring spun yarns. It was also found that compact spun yarns were superior to ring spun ones with respect to work of rupture by 12%.

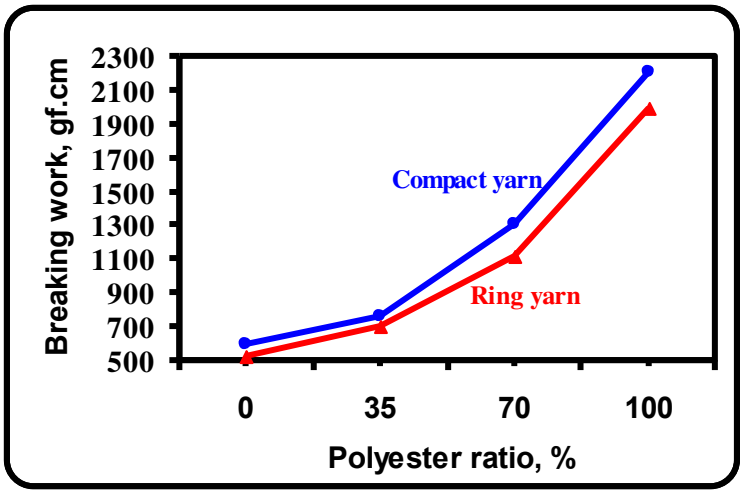

Fig. 3: Breaking work versus polyester ratios for compact and ring cotton/ polyester blended yarns.

The regression models which correlate polyester ratios with breaking work of cotton/polyester compact and ring pun yarns have the following linear forms:

Breaking work, gf.cm (compact yarn) = 0.68 × polyester ratio +5.5
Breaking work, gf.cm (ring yarn) = 0.66 × polyester ratio +4.75

The correlation coefficients of these models were found to equal 0.955 and 0.81 for compact and ring spun yarns respectively. This means that polyester ratio has a positive and strong correlation with breaking work of blended spun yarns.

Imperfection index

The total number of thick places, thin places and neps per one kilometer of yarn length was termed as imperfection index. The variation of imperfection index of cotton/polyester blended yarn at different level of polyester ratios was illustrated in figure 4. It was proved that polyester ratio and spinning system types have a huge influence on cotton/polyester blended yarn imperfection index. The higher the polyester ratio, the higher is the imperfection index. It was found that the effect of polyester ratio and the type of spinning technique accounted for 66% and 32% the effects on the yarn imperfection index. It was also estimated that increasing the polyester ratio leads to an increase in the blended yarn imperfection index by approximately 40% for both compact and ring spinning methods.

It was also shown that irrespective the value of the polyester ratios, cotton/polyester compact spun yarn exhibited higher values of imperfection index compared to their counter parts spun from ring spinning technique. The imperfection index associated with compact cotton/polyester blended yarn was higher than that of ring blended yarn by approximately 20%.

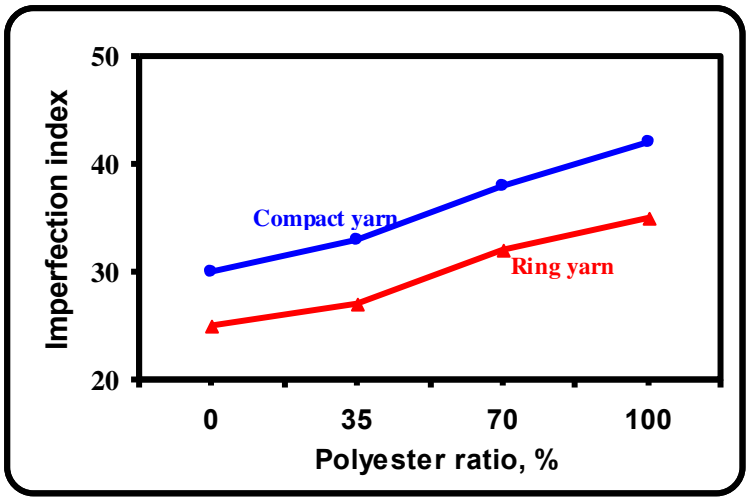

Fig. 4: Imperfection index versus polyester ratios for compact and ring cotton/ polyester blended yarns.

The regression models which correlate the imperfection index of cotton/polyester blended yarn with polyester ratio have the following forms:

Imperfection index (compact yarn) = 4.1 × polyester ratio + 25.5
Imperfection index (ring yarn) = 3.5 × polyester ratio + 21

The correlation coefficients of these models were found to equal 0.992 and 0.976 for compact and ring spun yarns respectively. This means that polyester ratio has a positive and strong correlation with imperfection index of blended spun yarns under study.

Hairiness index

The variation of hairiness index of cotton/polyester blended yarns produced from compact and ring spinning system according to the variation of polyester ratios was presented in figure 5. The statistical analysis improved the significance impact of both polyester ratios and the type of spinning method on the hairiness index of blended yarns. It was estimated that the effects of spinning type and the ratio of polyester on the of cotton:polyster blended yarn accounted for 37% and 52% of the effects on hairiness index respectively. From this figure it can be noticed that hairiness index of the cotton:polyester blended yarns diminishes significantly with increasing the polyester ratio. Increasing the polyester ratio resulted in the reduction in the hairiness index by about 14% and 17% for ring and compact blended yarns respectively.

Irrespective of the value of polyester ratio compact blended spun yarns exhibited lower hairiness index compared ring blended spun yarns by approximately 10% which has been confirmed by several researches [12-15]. The lower hairiness associated with compact cotton: polyester blended yarn may be due to the compactness and the incorporated of the outer and edge fibers in the yarn structure accompanied by this type of spinning techniques.

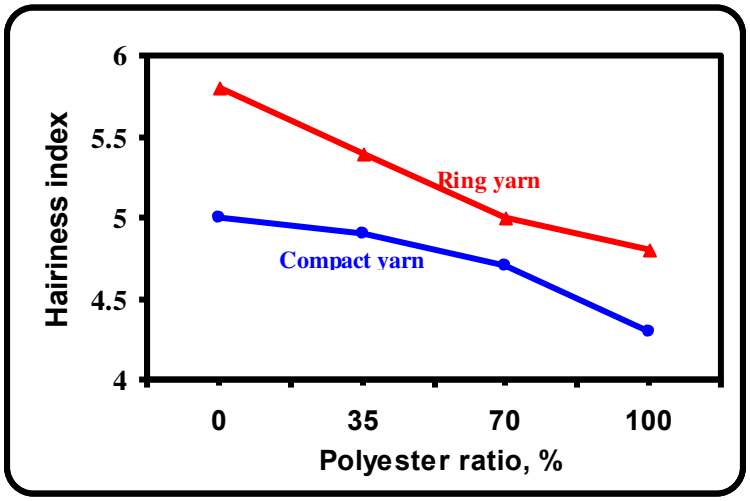

Fig. 5: Hairiness index versus polyester ratios for compact and ring cotton/polyester blended yarns.

Regression models which correlate the polyester ratios with hairiness index o compact and ring blended yarns have the following straight lines:

Hairiness index (compact yarn) = -0.23 × polyester ratio + 5.2
Hairiness index (ring yarn) = -0.34 × polyester ratio + 6.1

The correlation coefficients of these models were found to equal -0.92 and 0.979 for compact and ring spun yarns respectively. This means that polyester ratio has a negative and strong correlation with hairiness index of blended spun yarns.

Yarn irregularity

The measure of variation of yarn linear density or the variation of its mass per unit length is termed as yarn irregularity. Generally, yarn irregularity points out to the variation of yarn count along its length. Yarn irregularity is denoted by CV which means the coefficient of variation. It was found that the higher the CV, the higher the yarn irregularity is [12].

The variation of irregularity of compact and ring cotton: polyester blended yarns according to the variation of polyester ratios were depicted in figure6. It was determined that polyester ratio and spinning type accounted for 80% and 15%

respectively of the effects on yarn irregularity. From this figure it can be seen that as the polyester ratio increases the yarn irregularity has the same trend for both types of yarns.

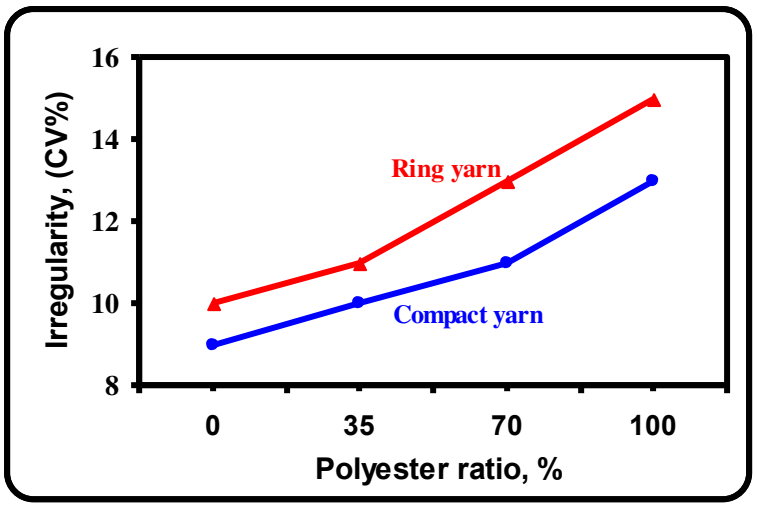

Fig. 6: Irregularity versus polyester ratios for compact and ring cotton/polyester blended yarns.

Increasing polyester ratio from zero to hundred percent leads to augmented the irregularity of compact and ring cotton:polyester blended yarns by about 40% and 50% respectively. It is also shown and as expected that compact cotton: polyster blended yarn has more evenness than ring blended yarns. This is because the improved fiber integration and the rduction of fiber loss for yarn surface associated with compact spinning technique [12].

The relation between polyster ratio and irregularity of comapct and ring cotton:polyetsr belnded yarns has the following linear forms:

Irregularity, CV% (compact yarn) = 1.3 × polyester ratio + 7.5
Irregularity, CV% (ring yarn) = 1.7× polyester ratio + 8

The correlation coefficients of these models were found to equal 0.956 and 0.979 for compact and ring spun yarns respectively. This means that polyester ratio has a positive and strong correlation with hairiness index of blended spun yarns.

Conclusion

Blending of cotton with polyester fibers is considered one of the most popular type of blending in the textile sector because the wonderful aesthetic and functional properties which can be obtained for the products made from them. In this

study mixing of polyester fibers with different ratios and cotton fibers on compact and ring spinning techniques were conducted and compared. The conclusion of this study can be drawn as follows:

- To large extent, polyetsr ratios were found to have a huge influence on the aesthetic and functional properties of compact and ring cotton:polyester blended yarns.

- Tensile properties and hairiness index were enhanced while yarn evenness and imperfection were deteriorated significantly by increasing polyester ratios for both compact and ring blended yarns.

- By and large, and as expected, compact cotton: polyester blended yarns were superior to their counterparts made form ring yarns with respect to tensile properties, hairiness index and yarn evenness.

- Linear models which correlate polyester ratios to the blended yarn properties were derived using regression analysis. These models were validated using the correlation coefficient, which ranges between +1 and -1. It was estimated that these models can be used to predict the properties of the blended yarns effectively.

References

1- Alsaid Ahmed Almetwally and M.M. Mourad. Effects of spandex drawing ratio and weave structure on the physical properties of cotton/ spandex woven fabrics. The Journal of the Textile Institute, Vol. 105, No. 3, 235–245, 2014.

2- Alsaid Ahmed Almetwally, Hatim M.F. Idrees & Ali Ali Hebeish. Predicting the tensile properties of cotton/spandex core-spun yarns using artificial neural network and linear regression models. The Journal of the Textile Institute, Vol. 105, No. 11, 1221–1229, 2014.

3. Duckett KE, Goswami BC, Ramey Jr HH (1979) Mechanical Properties of cotton/polyester yarns. Textile Res J 49: 262-267.

4. Gupta DK, Shiekl AE (1975) The Mechanics of blended yarns. Appl Polym Symp 27: 295-315.

5. Azzouz B, Hassen MB, Sakli F (2008) Adjustment of cotton fibre length by the statistical normal distribution: Application to Binary Blends. Journal of Engineered Fibres and fabrics 3: 35-46.

6- Haque MM and Maruf NH. Evaluation of Processing performance and properties of 100% cotton and cotton-polyester blended ring yarns. Journal of textile science and engineering, Vol. 6, No. 2, 2016.

7. Jamil N, Shahbaj B, Iftikhar M, Haq Z (2004) Int J Agricult Biol 6: 1053

8. Svetnickiene V, Ciukas R (2009) Investigation of frictional properties of yarns from natural fibres. Mechanika 1: 73-76.

9. Smriti SA, Islam A. An exploration on pilling attitudes of cotton polyester blended single jersey knit fabric after mechanical singeing. Science Innovation 3: 18-21, (2015).

10- Behera, B. K. Comfort and handle behavior of linen-blended fabrics. AUTEX Research Journal, Vol. 7, No 1, March 2007.

11- M. M. Mourad, Ahmed El-Salmawy, and Alsaid Ahmed Almetwally. Core spun yarn and the secret behind its popular appeal, Textile Asia, 2011, November,42 (10), 41-43.

12- Alsaid Ahmed Almetwally, M M Mourad, Ali Ali Hebeish & Mohamed A Ramadan. Comparison between physical properties of ring-spun yarn and compact yarns spun from different pneumatic compacting systems. Indian Journal of Fibre & Textile Research Vol. 40, March 2015, pp. 43-50.

13- M.A. Saad and Alsaid A. Almetwally. Spinning techniques vs. yarn properties. Textile Asia, volume XXXVIX No. 7, PP 35-41, July 2008.

14- Karifa M & Ethridge M D, *Text Res J*, 76 (5), (2006) , 388.

15- Tyagi G, Bhowmick M, Bhattacharyya S & Kumar P, *Indian J Fibres Text Res*, 35 (2010) 21.