Ali Kireçci, Hatice Kübra Kaynak, Mehmet Erdem Ince

Comparative Study of the Quality Parameters of Knitted Fabrics Produced from Sirospun, Single and Two-ply Yarns

University of Gaziantep, Department of Textile Engineering,
27310 Gaziantep, Turkey
E-mail: kirecci@gantep.edu.tr, tuluce@gantep.edu.tr, eince@gantep.edu.tr

Abstract
This study aimed to examine the quality parameters of knitted fabrics produced from sirospun, single and two-ply yarns. To achieve this, knitted fabrics were produced from these yarns with yarn numbers of 29.5 tex, 33 tex and 37 tex. Then sirospun yarn fabrics with 6 mm, 8 mm and 11 mm strand spacings were produced to observe the effect of strand spacing on fabric quality parameters. The experimental results show that the unevenness, hairiness, strength and elongation values of sirospun yarns are similar to or better than those of single and conventional plied yarns for all samples. However, enlarging the strand spacing causes small reductions in hairiness, strength and elongation values. The results of the fabric performance test show that the bursting strength, abrasion resistance and pilling resistance of sirospun yarn fabrics are as good as those of single and conventional plied yarn fabrics. However, the spirality values of plied yarn fabrics are slightly lower than those of sirospun yarn fabrics at finer yarn count values. These results indicate that sirospun yarn may be a good alternative for plied yarn due to its extremely low production cost and high quality values.

Key words: *two-strand spinning, sirospun, fabric quality, strand spacing.*

Introduction

The yarn plying and twisting together of fibre streams causes a decrease in the linear mass irregularity, an increase in the tenacity, a lowering of the bending stiffness, an increase in the abrasion resistance, and a lowering of the thread's tendency towards pilling formation [1]. The plying process is usually applied in short staple spinning to improve the strength and irregularity properties of yarn. In recent years, two-strand spinning, which was essentially designed for wool raw material, has become widespread as an alternative to the conventional plying of short staple yarns. This system is a modified ring spinning system and is already known as siro-spinning. In this system two rovings are fed to a ring frame, with separators to ensure that each roving is drafted individually. Emerging from the nip point of the front rollers of the drafting system, the two strands start to twist together at a convergence point. In this way a plied yarn is formed before the pigtail guide. Undoubtedly, integrating the plying process with yarn production is a very important advantage of this system, resulting in the production cost of the product being greatly reduced. Keeping this advantage in mind, many researchers have attempted to produce short staple yarn with this system. Cheng and Sun studied the effect of strand spacing and twist multiplier on the properties of combed cotton sirospun yarn. They observed decreasing yarn hairiness and increasing yarn abrasion resistance when the strand spacing was increased. On the other hand, yarn tenacity was increased to a maximum and then decreased by increasing the twist multiplier [2]. Sun and Cheng reported another research on the relationship between the twist multiplier and cotton yarn properties of sirospun, plied and single yarns. According to this research, sirospun yarn has higher tenacity than single yarn for all twist multipliers. Moreover sirospun yarn showed better tenacity than two plied yarn when the twist multiplier was increased. Furthermore sirospun yarn was the least hairy and more abrasion resistant for all twist multipliers [3]. Su, Liu and Jiang investigated optimum drafting conditions for siro spinning by changing the roving spacing using lyocell roving. They studied the correlation between the drafting force and yarn properties. Their observations showed that a wider spacing of the twin roving resulted in more yarn breakage [4]. Gokerneshan, Anbumani and Subramaniam investigated the influence of strand spacing on interfiber cohesion in cotton, cotton/polyester and polyester sirospun yarns. Maximum cohesion was observed at the lowest strand spacing for all yarn types. In addition to this, for all yarn types, yarn tenacities increased up to a maximum and then decreased by increasing strand spacing [5]. Salhotra used finer rovings which require a lower draft to produce good quality viscose sirospun yarn. There was a substantial decrease in yarn irregularity as the draft was reduced. On the other hand, yarn imperfections do not reveal any consistent trend with a change in the draft [6]. Subramaniam and Natarajan examined the dependence of strand spacing and twist on the coefficients of friction for cotton, polyester/cotton, and viscose sirospun yarns. Increasing the strand spacing and twist increased the frictional coefficient for all three yarn types [7]. Chu and Cheng experimentally compared two-ply and sirospun carded cotton yarns of different strand spacing. The abrasion resistance, hairiness, strength and uniformity of sirospun yarn was found better than those of two-ply yarn [8].

Ghasemi et al. studied the effects of yarn twist factor on wool/polyester yarn properties which were produced by sirospun and solo-sirospun technologies. According to this study yarn hairiness was improved by solo-sirospun process while tensile strength, elongation and yarn abrasion resistance remained unchanged [9]. In addition to these studies, many studies are available on dynamical modeling on sirospun and sirofil yarn spinning [10 - 12].

Vijayakumar investigated the properties of weft knitted fabrics made from cotton sirospun and ring hosiery yarn. The researcher observed lower dimensional stability and higher bursting strength for sirospun yarn fabric than for ring yarn fabric. As regards comfort properties, there is not much difference between the two types [13].

Helw, Hawary and Okeily compared the properties of weft knitted fabrics produced from cotton sirospun, single ring spun and two ply ring spun yarns. They

Kireçci A., Kaynak H. K., Ince M. E.; Comparative Study of the Quality Parameters of Knitted Fabrics Produced from Sirospun, Single and Two-ply Yarns. FIBRES & TEXTILES in Eastern Europe 2011, Vol. 19, No. 5 (88) pp. 82-86.

Table 1. *Fibre properties.*

Parameter, Unit	Value
Fiber fineness, Micronaire	4.06
Fiber length, mm	28.3
Uniformity index,%	82.4
Short fiber index	9
Fiber strength, g/tex	31.5
Elongation,%	6.4
Spinning consistency index	140

Table 2. *Production parameters of sirospun yarns.*

Production parameters, unit	Value
Number of card slivers, tex	4922
Number of draw frame slivers, tex	4922
Number of rovings, tex	422
Diameter of ring, mm	45
Spindle revolution, rev/min	11500
Yarn twist multiplier, α_e	3.5

observed that sirospun yarn fabrics had the highest abrasion resistance and lowest bursting strength of all the types examined. The crease recovery of sirospun fabrics was almost of the same level as that two ply yarn fabric and higher than that of single yarn fabric [14].

In another research done by Sun and Cheng, cotton knitted fabric from sirospun and two fold yarn were compared. Sirospun yarn fabrics had a higher bursting strength, pilling resistance, abrasion resistance and thermal conductivity than two fold yarn fabrics. Sirospun yarn fabric was thicker, softer, less smooth, had poorer recovery from compression, less stiff and less air permeable than two-fold yarn fabrics. On the other hand sirospun yarn fabrics had lower dimensional stability and higher spirality after washing [15].

There are many studies on sirospun yarn quality parameters in the literature, but just a few studies have determined the quality parameters of knitted fabrics produced from sirospun yarns. Therefore this experimental study aimed to compare the quality parameters of knitted fabrics produced from sirospun, single and two-ply yarns. In addition the effects of strand spacing on fabric quality parameters were examined with respect to sirospun yarns.

Experimental

In this study combed cotton fiber was used for the production of sample yarns. The fiber properties were determined using a Uster HVI, the results of which are given in ***Table 1***.

In this study the fiber was combed to improve the material quality. Fifteen yarn samples were produced from the same raw material and with the same production parameters, as shown in ***Table 2***.

The yarn samples were produced with linear densities of 29,5 tex, 33 tex and 37 tex. For each linear density, five yarn samples were produced as single, two-plied, sirospun with a 6 mm strand spacing, sirospun with an 8 mm strand spacing and sirospun with an 11 mm strand spacing. ***Figure 1*** shows the production process of sirospun yarn.

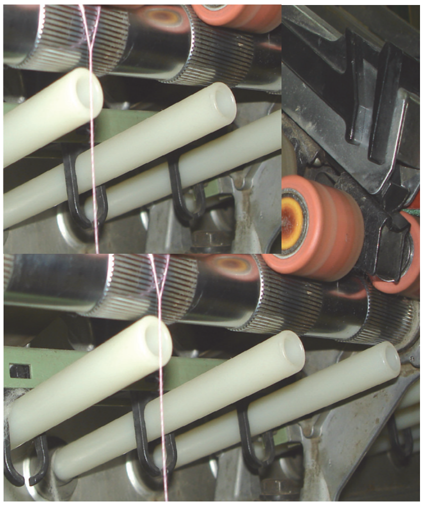

Figure 1. *Production process of sirospun yarn.*

Single, two-plied and sirospun yarn samples were knitted on a 3.5 inch diameter sample knitting machine at a machine speed of 200 rev/min.

All the yarn and fabric samples were conditioned at 20 ± 2 °C and 65 ± 4% relative humidity for 8 hours according to ISO 139 before the measurements and tests. The thickness of the fabric samples were measured by a Paramount thickness tester according to ISO 5084. The number of courses and wales were determined using a magnifying glass at 5 randomly selected regions of the sample fabrics. To determine the loop length, 50 alongside loops were cut by a blade, and yarn was unraveled from this region. Then the length of this yarn was measured after decrimping. The yarn length of the loop was calculated by dividing the value measured by 50. An average of six measurements was taken for each sample, the results of which are given in ***Table 3***.

The yarn samples were tested with an Uster Tester 4 to obtain yarn quality parameters. Five bobbins were tested and 1 measurement was performed for each bobbin. Yarn breaking strength and yarn breaking elongation values were determined by means of 10 measurements for each sample using an Uster Tensorapid 4. The spirality of the sample fabrics was determined after dry relaxation according to IWS 276, and five measurements were performed for each fabric sample. A Truburst bursting strength tester was used to determine the bursting strength properties of the fabric samples according to ISO 13938-2 for pneumatic measurements. A 7.3 cm^2 test area was used, and an average of five measurements was taken for each sample. To determine the abrasion resistance of the fabrics, the fabric samples were tested according to

Table 3*. Fabric properties of samples.*

Samples	Loop length, cm	Thickness, mm	Number of courses/10 cm	Number of wales/10 cm
29.5 tex sirospun. 6 mm strand spacing	0.40	0.59	16	11
29.5 tex sirospun. 8 mm strand spacing	0.43	0.61	16	11
29.5 tex sirospun. 11 mm strand spacing	0.43	0.51	16	11
33 tex sirospun. 6 mm strand spacing	0.37	0.65	17	11
33 tex sirospun. 8 mm strand spacing	0.38	0.62	17	10
33 tex sirospun. 11 mm strand spacing	0.37	0.65	17	10
37 tex sirospun. 6 mm strand spacing	0.36	0.65	18	10
37 tex sirospun. 8 mm strand spacing	0.37	0.65	18	10
37 tex sirospun. 11 mm strand spacing	0.36	0.65	18	10
29.5 tex two-ply	0.36	0.60	18	10
33 tex two-ply	0.36	0.60	18	10
37 tex two-ply	0.36	0.65	18	11
29.5 tex single	0.41	0.59	16	11
33 tex single	0.38	0.65	17	10
37 tex single	0.37	0.69	18	10

ASTM D 4966-98 using a Martindale abrasion and pilling tester. The abrasion resistance was determined from the mass loss after 5000, 10000, 15000 and 20000 abrasion cycles by taking the average value of four samples of each fabric. These values were then expressed as a percentage of the initial mass. The Martindale abrasion and pilling tester was used according to ISO 12945-2 for pilling resistance. Three specimens were tested for each sample fabric. The appearance of the specimens after 125, 500, 1000, 2000, 5000 and 7000 cycles of the testing device was assessed according to ASTM pill grade photographic views.

Results and discussion

Yarn Properties

Yarn unevenness (CVm%) values of sirospun, single and plied yarns for 29.5 tex, 33 tex and 37 tex yarn linear densities are given in ***Figure 2***. Generally, yarn evenness deteriorates when the yarn linear density is decreased. On the other hand, there is no significant difference between the evenness values of the samples for a strand spacing of 6, 8 and 11 mm. A similar result was obtained by Cheng and Sun in earlier researches [2, 3].

The number of thin places (-40%/km), thick places (+50%/km) and neps (+200%/km) of sirospun, single and plied yarns are exhibited in ***Figures 3, 4*** and ***5***, respectively. The yarn samples do not show a consistent variation with respect to yarn imperfections. Thus the experimental study shows that two-strand spinning has no effect on yarn imperfections.

Hairiness values of the samples are given in ***Figure 6***. Sirospun yarns have lower hairiness values than single and plied yarns. Additionally, it is obvious that wider strand spacing causes lower hairiness. On the other hand, the hairiness values of finer yarns are lower than those of coarser yarns.

Figure 7 shows breaking strength values of the yarn samples. The plied yarn samples usually have lower strength values than all the other samples. The single yarn samples have higher strength values than plied yarns but lower than sirospun yarns; however, the difference is not significant. Sirospun yarns of 6 mm and 8 mm strand spacing have almost equal strength values, but sirospun yarn of 11 mm strand spacing has the lowest strength of all the sirospun yarns.

Figure 8 shows breaking elongation values of the yarn samples. The plied yarn samples have the lowest elongation value for all three yarn linear densities. This is an expected result: the conventional plying process decreases the breaking elongation. On the other hand, the single yarn types have similar breaking elongation values to those of the sirospun yarn types; however, the elongation values of sirospun yarns decrease slightly as the linear density decreases.

Fabric properties

Spirality

Fabric spirality values of the sample fabrics are given in ***Figure 9***. Single yarn fabrics exhibit considerably higher spirality values than the others. On the other hand, plied yarn fabrics have lower values than the sirospun yarn samples for linear densities of 33 tex and 37 tex yarn; however, the sirospun yarn sample shows better spirality for a yarn linear density of 29.5 tex. Better spirality values are obtained at a strand spacing of 8 mm for all yarn linear densities only with respect to sirospun yarns.

Bursting strength

Bursting strength values of the sample fabrics are given in ***Figure 10***. Plied yarn fabrics have lower bursting strength values than single and sirospun yarn fabrics for all yarn linear densities, contrary to Sun and Cheng [15]. However, the fabric samples with sirospun and single yarns have very similar bursting strength values for all yarns. Moreover, it was observed that an increasing yarn linear density has a decreasing effect on the burst-

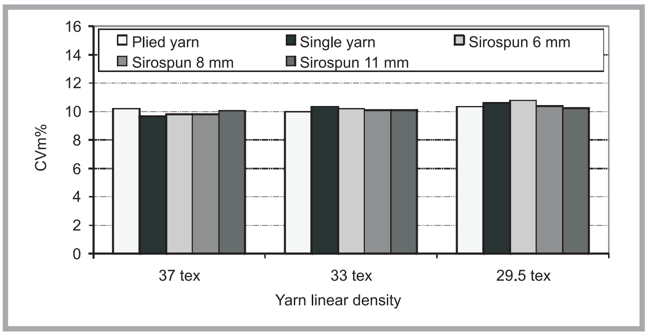

Figure 2. *Yarn unevenness.*

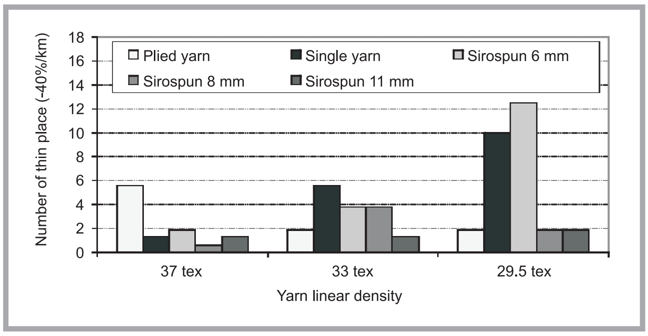

Figure 3. *Number of thin places.*

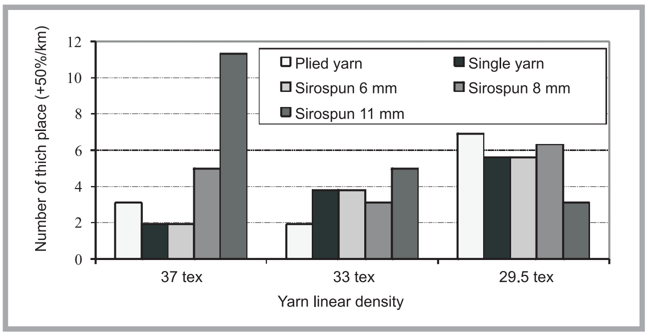

Figure 4. *Number of thick places.*

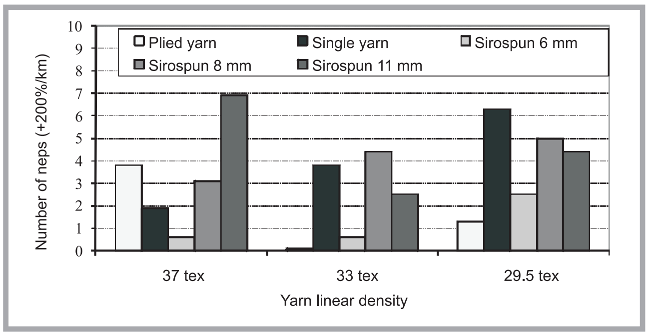

Figure 5. *Number of neps.*

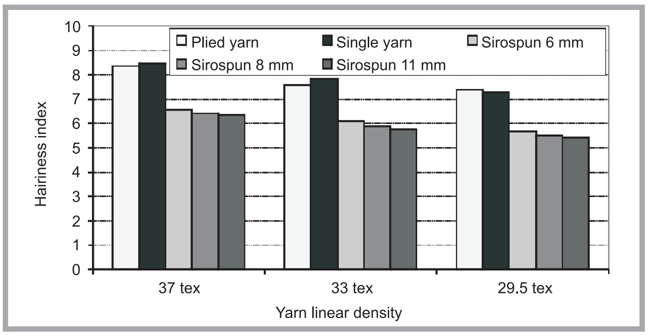

Figure 6. Hairiness.

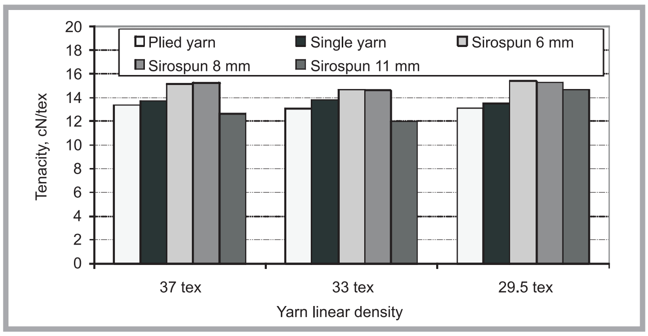

Figure 7. Yarn breaking strength.

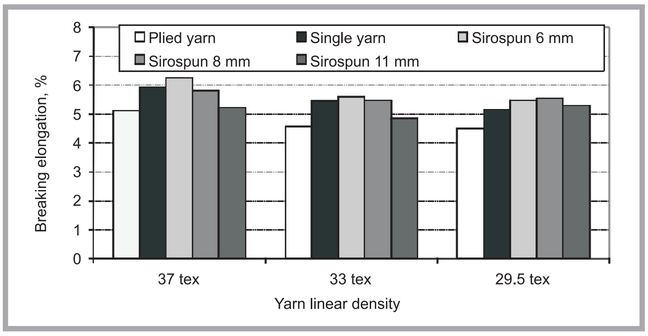

Figure 8. Yarn breaking elongation.

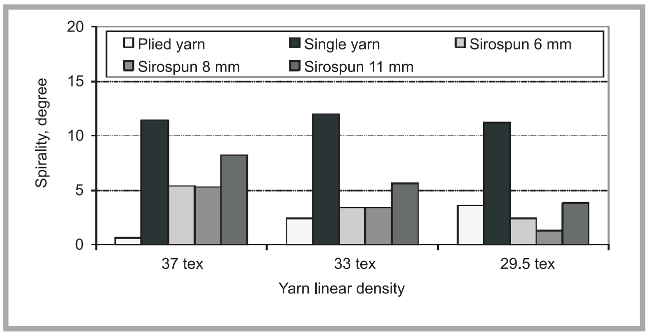

Figure 9. Fabric spirality.

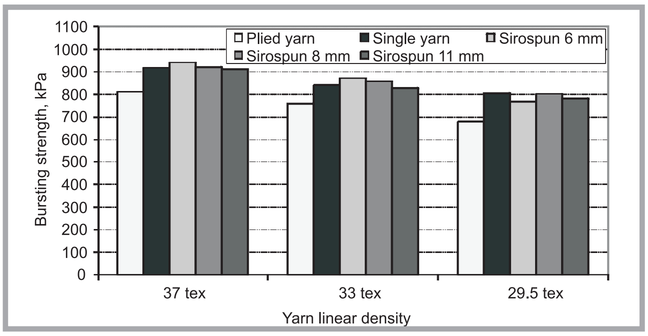

Figure 10. Fabric bursting strength.

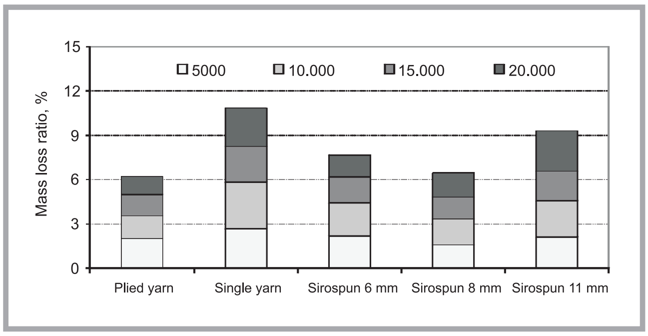

Figure 11. Mass loss ratio of 37 tex yarn fabrics.

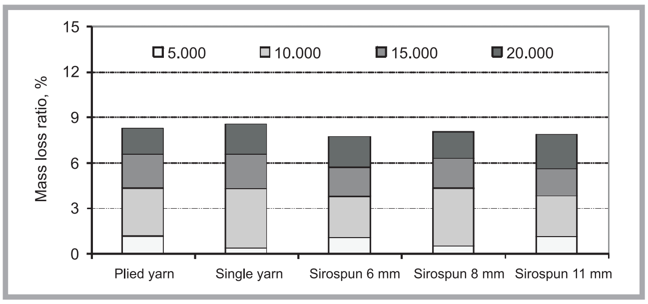

Figure 12. Mass loss ratio of 33 tex yarn fabrics.

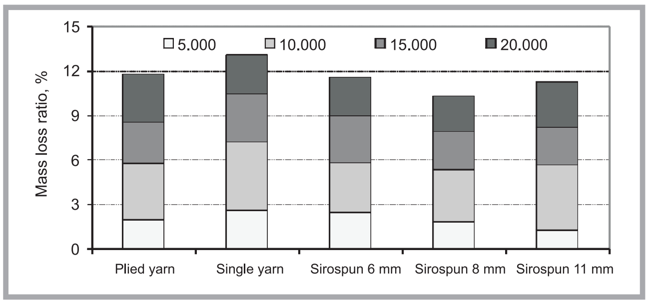

Figure 13. Mass loss ratio of 29.5 tex yarn fabrics.

ing strength for all the fabric types, as expected. Also, the experimental results obviously show that there is a correlation between yarn breaking strength and bursting strength values (see ***Figures 7*** and ***10***, respectively). Accordingly, the fabric samples produced from sirospun yarn with an 8 mm strand spacing show better bursting strength values when only sirospun yarn samples are compared.

Abrasion resistance

Abrasion resistance results of the sample fabrics are given in ***Figures 11, 12*** and ***13***, respectively. Single yarn fabric has the highest and plied yarn fabric has the lowest mass loss values for 37 tex yarn fabrics; however, sirospun yarn fabrics come between these, as shown in ***Figure 11***. In the case of 33 tex yarn fabrics, all the mass loss values are similar to each other, and there is no considerable mass difference between the samples; but the sirospun yarn samples show better re-

Table 4. Pilling degrees of fabric samples produced from 37 tex, 33 tex and 29.5 tex yarn.

Yarn	Pilling cycle	Pilling degrees				
		Plied yarn	Single yarn	Sirospun		
				6 mm	8 mm	11 mm
37 tex	125	4	4	4	4	4
	500	3	3	3	3	3
	1000	3	3	3	3	3
	2000	3	3	3	3	3
	5000	2	2	2	2	2
	7000	2	2	2	2	2
33 tex	125	4	4	4	5	4
	500	4	3	4	4	4
	1000	3	3	4	4	4
	2000	3	2	4	3	3
	5000	2	2	3	2	2
	7000	2	2	2	2	2
29.5 tex	125	4	4	4	4	4
	500	4	3	3	3	3
	1000	4	3	3	3	3
	2000	3	3	3	3	3
	5000	3	2	3	3	3
	7000	3	2	2	2	2

sults than the others. The results of the 29.5 tex yarn samples were quite similar to those of the 33 tex yarn samples; but a higher amount of mass losses were observed, as shown in ***Figure 13***. In general, the results of the abrasion test show that the amount of mass loss rises as the linear density of the yarn decreases. In addition to this, plied yarns have a higher abrasion resistance with coarser yarns, but sirospun yarn fabrics show better abrasion resistance than single and plied yarn fabrics as the yarns become coarser. The most effective abrasion resistance of sirospun yarn fabrics was observed for a strand spacing of 8 mm.

Pilling resistance

The pilling degrees of the fabric samples are given in ***Table 4***. Sirospun yarns generally have low hairiness values, as seen in ***Figure 6***. Therefore, less pilling was expected for the fabrics made of these yarns; however, contrary to this estimation, two-strand spinning technology has no distinct effect on the pilling behaviour of knitted fabrics with respect to single and plied yarns.

Conclusions

This paper compares the properties of fabrics produced from sirospun, single and two-ply yarns. It is known that the yarn plying and twisting process improves the yarn and fabric quality parameters; however, it also increases the cost of the process considerably. Sirospun yarn is an alternative method of producing plied yarns that integrates the plying and spinning processes on a ring spinning machine. The experimental results show that the hairiness values of sirospun yarns are clearly lower than those of single and plied yarns, as a result of which less pilling was expected from the fabrics produced from sirospun yarns. However, the practical pilling tests illustrate that there is no difference in pilling resistance between the samples for all yarn linear densities. Sirospun yarns produce higher yarn breaking strength values than single and plied yarns, hence the bursting strength values of fabrics produced from sirospun yarns are better than those of the others, as expected. In addition, plied yarn fabrics produce, to some extent, higher abrasion values for coarser yarns, whereas sirospun yarn fabrics generate higher abrasion values for finer yarns. Spirality tests show that single yarn fabrics produce poor spirality values. Plied yarn fabrics produce lower spirality at a higher yarn linear density, whereas sirospun yarns fabrics have a tendency to produce better spirality as the yarn linear density decreases. Consequently, the test results show that sirospun yarn fabrics are superior to those produced from single and plied yarns. The strand spacing for sirospun yarn production has a definite effect on the yarn properties and fabric performance. The most successful results are obtained at a strand spacing of 8 mm, but a very short or too long strand spacing negatively influences those quality parameters.

References

1. Rosiak D., Przybyl K.; "Twisting of multi-folded yarns and threads manufactured by means of new spinning Technologies", Autex Research Journal, Vol. 4, No. 3, 2004, pp. 113-117.
2. Cheng K. P. S., Sun M. N.; "Effect of strand spacing and twist multiplier on cotton sirospun yarn", Textile Research Journal, Vol. 68, No. 7, 1998, pp. 520-527.
3. Sun M. N., Cheng K. P. S.; "Structure and properties of cotton sirospun yarn", Textile Research Journal, Vol. 70, No. 3, 2000, pp. 261-268.
4. Su C. I., Liu C. H., Jiang J. Y.; "Drafting force of twin spun yarn", Textile Research Journal, Vol. 73, No. 9, 2003, pp. 815-818.
5. Gokarneshan N., Anbumani N., Subramaniam V.; "Influence of strand spacing on the interfibre cohesion in siro yarns", Journal of the Textile Institute, Vol. 98, No. 3, 2007, pp. 289-292.
6. Salhotra K. R.; "Quality improvement of sirospun yarns through use of finer rovings", Textile Research Journal, Vol. 60, No. 11, 1990, pp. 687-689.
7. Subramaniam V., Natarajan K. S., "Frictional properties of siro spun yarns", Textile Research Journal, Vol. 60, No. 4, 1990, pp. 234-239.
8. Chu S. P., Cheng S. K. P.; "Sirospun versus two-ply", Textile Asia, Vol. 26, No. 5, 1995, pp. 48-57.
9. Ghasemi R., Mozafari-Dana R., Etrati S. M., Shaikhzadeh Najar S.; "Comparing the physical properties of produced sirospun and new hybrid solo-siro spun blend wool/polyester worsted yarns", Fibres &Textiles in Eastern Europe, Vol. 16, No. 1, 2008, pp. 24-27.
10. He J. H., Yu Y. P., Yu J. Y., Li W. R., Wang S. Y.; "A linear dynamic model for two-strand yarn spinning", Textile Research Journal, Vol. 75, No. 1, 2005, pp. 87-90.
11. He J. H., Yu Y. P., Yu J. Y., Li W. R., Wang S. Y., Pan N.; "A nonlinear dynamic model for two-strand yarn spinning". Textile Research Journal, Vol. 75, No. 2, 2005, pp. 181-184.
12. Zhang L. N., He J. H.; "Periodic and Chaotic Motion in Sirofil Yarn Spinning", Fibres&Textiles in Eastern Europe, Vol. 16, No. 2, 2008, pp. 27-29.
13. Vijayakumar H. L., Muralidhara J. S., Swamy J. S. S., Benal V. S., Sirnath K. V.; "Weft knitted fabrics from siro and ring spun hoisery yarn", Indian Textile Journal, Vol. 101, No. 4, 1991, pp. 62-64.
14. Helw E. M., Hawary I., Okeily M.; "Weft knitted fabrics from siro and ring-spun yarns", Indian Textile Journal, Vol. 98, No. 11, 1988, pp. 134-42.
15. Sun M. N., Cheng K. P. S.; "The quality of fabric knitted from cotton sirospun yarn", International Journal of Clothing Science and Technology, Vol. 12, No. 5, 2000, pp. 351-360.

Received 07.12.2009 Reviewed 06.09.2010