ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

ANALYSING THE PHYSICAL AND MECHANICAL PROPERTIES OF CORE-SPUN YARNS

BALCI KILIC Gonca[1]

[1] Dokuz Eylül University, Faculty of Engineering, Department of Textile Engineering, 35397, İzmir, Turkey

Corresponding author: BALCI KILIC, Gonca, E-Mail: gonca.balci@deu.edu.tr

Abstract: *Core spun yarn is also named as complex, compound, composite or hybrid yarn can be defined as the combination of filament and staple fibres. A filament which is called core is covered by staple fibres called sheath. In this study, it was aimed to analyse physical and mechanical properties of ring core-spun and ring dual core-spun yarns. Moreover, conventional ring and OE-rotor yarns were used as reference materials for better assessment. For this purpose, unevenness and imperfections, hairiness, frictional properties and tensile properties of yarns were measured. It was observed that core and dual-core spun yarns have better unevenness and imperfections values than conventional ring and OE-rotor spun yarns. Also, friction coefficients of core and dual-core yarns for all surfaces (yarn, metal and ceramic) were found lower than the equivelant 100% cotton conventional ring and OE-rotor spun yarns. Results showed that ring yarns have the highest hairiness values and it was also found that there is no statistically significant difference between hairiness values of core-spun and dual-core yarns. When the breaking force and breaking elongation were examined, it was seen that dual-core yarns have the highest values whereas OE-rotor yarns have the lowest.*

Key words: *Core-spun yarn, dual-core yarn, ring spinning, OE-rotor spinning, yarn hairiness, yarn friction*

1. INTRODUCTION

Core-spun yarn can be defined as the combination of filament and staple fibres and it is also named as acomplex, compound, composite or hybrid yarn. For the production of core spun yarns, filaments are fed into the axis of the yarn as core and staples are used to cover filaments as sheath. In this kind of yarn structure, it is possible to get benefit of either performance and recovery properties of filaments or comfort and surface properties of staples. The history of core-spun production is back to 1950s, a few years after highly utilized filaments were discovered. At present, core spun yarn production is done in different spinning technologies such as friction spinning, rotor spinning, air-jet spinning and ring spinning. However, ring spinning technology is most widely used technologies for core spun yarn production.

After the wide range of usage of core-spun yarn, researches have been continued to improve core spun yarn properties. In 2000s dual core-spun yarn was introduced. To produce dual-core spun yarn, two individual filaments with different properties fed into the axis of yarn. In general, polyethylene terephthalate-based filaments are used for high tensile properties while polyurethane based filaments are used for high recovery properties in dual-core spun yarn production.

Core-spun yarns have been in the center of many researches with the superior features against staple or filament yarns. The vast majority part of these studies examine the physical and mechanical properties of core-spun yarns and fabrics produced from these yarns. The effects of various parameters such as yarn linear density, yarn twist, core/sheath ratio, draft ratio, etc. were mostly studied [1, 2]. There are also many studies examine the electromagnetic shielding properties of fabrics produced from these yarns which are produced with electrically conductive filaments in the center of core-spun yarns [3, 4]. In recent years, many researchers have also focused on dual-core yarns produced using two different filaments in the core [5, 6].

Chakraborty and Chatterjee [7] examined the hairiness properties of silk-nylon core-spun yarns and they specified that core spun yarns have less number of protruding ends and loops than ring spun yarns. In another study, Tarafder and Chatterjee [8] analysed physical and mechanical properties of cotton covered nylon core-spun yarns. They stated that core spun yarns have better hairiness and abrasion resistance values than ring spun yarns. Jeddi et al. [9] compared the structural and mechanical properties of core-spun yarns with the 100% cotton ring spun yarns. They investigated the effect of yarn twist and pretension of the filament. Results showed that core-spun yarns have higher diameter, breaking strength and elongation and better unevenness and abrasion resistance than the equivelant 100% cotton conventional ring spun yarns. Babaarslan [10] examined that physical and mechanical properties of polyester/viscose staple and polyester/viscose core-spun yarns. It was pointed out that core positioning has a direct effect on the properties of the core-spun yarns and core-spun yarns have always higher hairiness than that of the staple yarn of the same fibers. Viswarajasekaran ve Raghunathan [11] analysed the physical properties of core-spun yarns. They remarked that tensile properties of core-spun yarns depend on core and sheath material, twist level and core/sheath ratio. They found that yarn irregularity decreases by reducing cotton content in the sheath and core-spun yarns have good tenacity and beraking extension as compared to yarns produced from conventional ring frame. Sue et al. [12] investigated the effect of draw ratio and feed-in angle on elastic recovery properties on core-spun yarns. They concluded that a higher feed-in angle provides a better cover effect and draw ratio of 3.5 yields better dynamic elastic recovery.

In this study, it was aimed to analyse and compare the physical and mechanical properties of conventional ring, OE-rotor and ring core-spun and ring dual core-spun yarns. For this purpose, unevenness and imperfections, hairiness, fricitonal properties and tensile properties of these yarns were measured and statistically analysed.

2. MATERIALS AND METHOD

In the study, 25 tex conventional ring, OE-rotor, ring core-spun and ring dual-core spun yarns were used. Properties of the yarns are given in Table 1.

Table 1: *Properties of the yarns*

Raw Material	**Spinning Technology**
Cotton	Ring
Cotton	OE-rotor
Sheath: Cotton, Core: Lycra (78 dtex)	Ring core-spun
Sheath: Cotton, Core: PBT (55 dtex), Core: Lycra (78 dtex)	Ring dual core-spun

Unevenness, imperfections and hairiness properties of yarns were measured by Uster Tester 5 at 400 m/min test speed. Breaking force (cN) and elongation (%) were measured by Instron 4411. Yarn-to-yarn, yarn-to-metal and yarn-to ceramic friction coefficient were tested by Lawson Hemphill (CTT) at 100 m/min test speed by using 25 cN input tension. Hairiness values (S1+2, S3) were also measured by Uster Zweigle Hairiness Tester 5 with 10 cN pretension.

3. RESULTS AND DISCUSSION

Physical and mechanical properties of ring, OE-rotor, core-spun and dual-core yarns were statistically analysed at $\alpha = 0.05$ significance level using ANOVA and confidence interval graphs at 95% were illustrated.

3.1 Unevenness and Imperfections

Mean values of unevenness (CVm%), thin places (-50% /km), thick places (+50% /km) and neps (+200% /km) are given in Table 2. ANOVA results are given in Table 3.

***Table 2:** Unevenness and imperfection values of yarns*

Spinning Tech.	CVm%	Thin Places -50%	Thick Places +50%	Neps +200%
Ring	14.46	1.5	207.5	256.5
OE-rotor	14.77	27.5	88.0	307.0
Core-spun	9.51	0.0	6.0	6.5
Dual-core	11.41	0.0	61.0	57.5

***Table 3:** ANOVA results of unevenness and imperfections*

Parameters	Sum of Squares	Mean Square	F	Sig.
CVm%	95.292	31.764	616.745	0.000*
Thin places -50%	2741.250	913.750	27.455	0.000*
Thick places +50%	108528.438	36176.146	108.545	0.000*
Neps +200%	324753.438	108251.146	460.950	0.000*

* Statistically significant at α=0.05.

When the unevenness and imperfections values of the yarns were examined, it was seen that ring and OE-rotor spun yarns have higher values than both core-spun yarns and effect of spinning technology is statistically significant at α=0.05 (Table 3). Moreover, cotton/Lycra core-spun yarns have the lowest unevenness and imperfections values.

3.2 Hairiness

Yarn hairiness values (H, sH, S1+2 and S3) of ring, OE-rotor, core-spun and dual-core yarns and 95% confidence interval plots are given in Fig. 1.

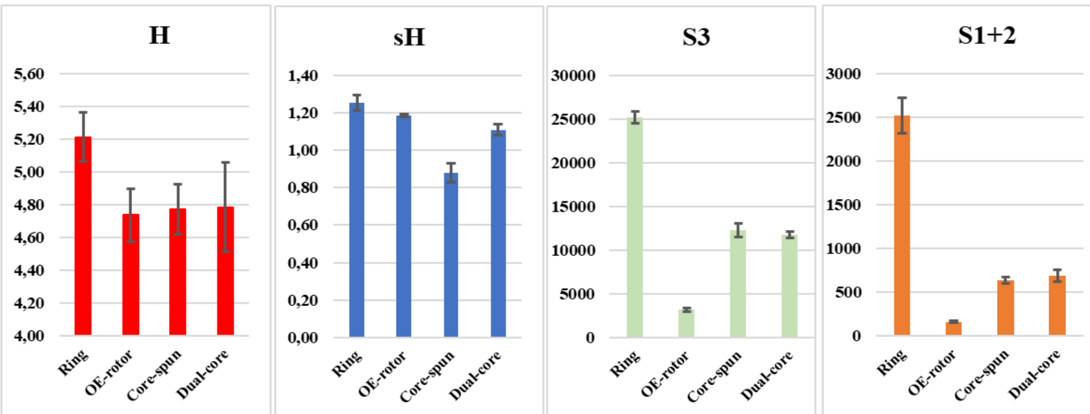

***Fig. 1**: Hairiness values and confidence interval plots of yarns*

Statistical analyses for the effects of spinning technology on yarn hairiness values (H, sH, S3 and S1+2) showed that spinning technology is statistically important. It was seen that ring yarns have the highest values for all hairiness parameters. Furthermore, pairwise comparisons show that there is no statistically significant difference between hairiness values (H and S3) of core-spun and dual-core yarns (Table 4).

Table 4: *Pairwise comparison of hairiness*

Yarn Property	Spinning Technology	Mean Difference |I-J|	Standard Error	Sig.
H	Ring/OE-rotor	0.476	0.097	0.000*
	Ring/Core spun	0.440	0.097	0.000*
	Ring/Dual-core	0.428	0.097	0.000*
	OE-rotor/Core-spun	0.036	0.097	0.715
	OE-rotor/Dual-core	0.048	0.097	0.627
	Core-Spun/Dual-core	0.012	0.097	0.903
S3	Ring/OE-rotor	2358.200	55.981	0.000*
	Ring/Core spun	1887.600	55.981	0.000*
	Ring/Dual-core	1829.200	55.981	0.000*
	OE-rotor/Core-spun	470.600	55.981	0.000*
	OE-rotor/Dual-core	529.000	55.981	0.000*
	Core-Spun/Dual-core	58.400	55.981	0.312

* Statistically significant at α=0.05.

3.3 Frictional Properties

In order to examine frictional properties of yarns, yarn-to-yarn, yarn-to-metal and yarn-to-ceramic friction coefficients were measured by CTT. Friction coefficients and confidence interval plots for ring, OE-rotor, core and dual-core yarns are given in Fig. 2.

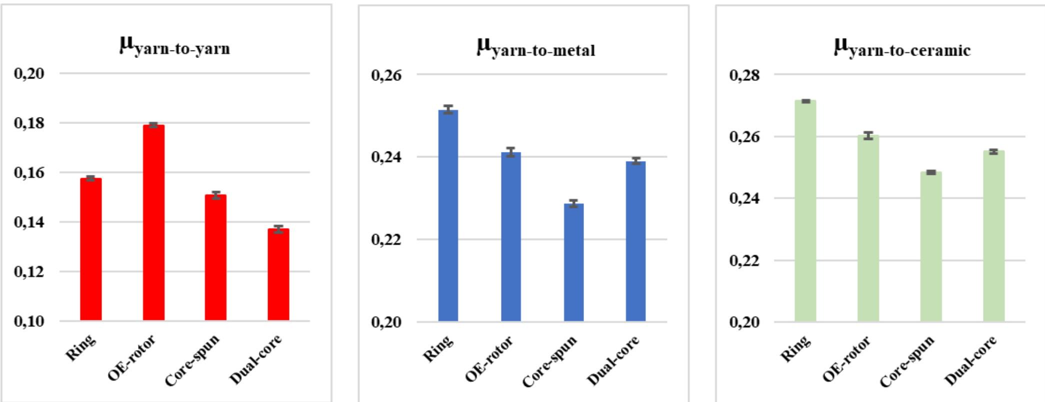

Fig. 2*: Friction coefficient values and confidence interval plots of yarns*

Yarn-to-metal and yarn-to-ceramic friction properties were calculated with Equation 1 (Capstan formula) and yarn-to-yarn friction properties were calculated with using Equation 2,

$$\mu = \frac{\ln(T_2 / T_1)}{4\pi(n-0.5)\sin\beta/2} \qquad \textbf{(1)}$$

$$\mu = \frac{\ln(T_2 / T_1)}{\theta} \quad \textbf{(2)}$$

where, T_2 is output tension, T_1 is input tension, β is 35º (lower apex angle between two yarns), n is the number of wraps (n=3) and θ is the cumulative wrap angle (radian).

When a general evaluation is made, the effect of spinning technology on yarn frictional properties is found to be statistically significant. Comparing yarn frictional properties of ring, OE-rotor, core and dual-core yarns showed that friction coefficient values of core and dual-core yarns are the lowest for all surfaces (yarn, metal and ceramic) (Figure 2). Besides, it was observed that ring yarns have the highest yarn-to-metal and yarn-to-ceramic friction coefficient, OE-rotor yarns have the highest yarn-to-yarn friction coefficient. This situation in yarn-to-material (metal and ceramic) friction can be explained by higher hairiness of ring yarns. Furthermore, wrapped structure of OE-rotor yarns may be the reason of higher yarn-to-yarn friction coefficient.

3.4 Mechanical Properties

In order to compare mechanical properties of yarns, breaking load (cN) and breaking elongation (%) were measured.

Mean values of breaking load and breaking elongation are given in Table 5. ANOVA results showed that spinning technology is important either breaking load or breaking elongation (Table 6).

Table 5: *Breaking load and breaking elongation values of yarns*

Spinning Technology	Breaking load (cN)	Breaking elongation (%)
Ring	362.54	8.05
OE-rotor	259.08	7.92
Core-spun	349.22	10.14
Dual-core	393.66	16.23

Table 6: *ANOVA results of breaking load and breaking elongation*

Parameters	Sum of Squares	Mean Square	F	Sig.
Breaking load	50077.197	16692.399	166.763	0.000*
Breaking elongation	227.876	75.959	963.217	0.000*

* Statistically significant at α=0.05.

As the breaking strength and breaking elongation values are examined, it is observed that the yarn produced in OE-rotor technology has the lowest values whereas dual-core yarns have the highest (Table 5).

4. CONCLUSIONS

In this study, physical and mechanical properties of ring, OE-rotor, core-spun and dual-core yarns were examined. In experimental part of the study, unevenness and imperfections, hairiness, frictional properties and tensile properties of the yarns were measured. Based on statistical analyses, it was seen that the effect of spinning technology is important for physical and mechanical properties of all yarn types. The unevenness and imperfection values of core-spun and dual-core yarns have the lowest values. For hairiness values, core-spun and dual-core yarns have lower values than conventional ring yarns. Moreover, it was observed that there are no statistically significant differences between H, S3 and S1+2 values for core-spun and dual-core yarns. When frictional properties of yarns were analysed, it was concluded that core-spun and dual-core yarns have the lowest friction coefficients for all surfaces (yarn, metal and ceramic). On the other hand, OE-rotor yarns have the highest yarn-to-yarn friction coefficient. Comparing breaking strength and breaking elongation values of yarns showed that OE-rotor yarns have the lowest values and dual-core yarns have the highest values.

REFERENCES

[1] M. B. Qadir, T. Hussain, M. Malik, F. Ahmad and S. H. Jeong, *"Effect of elastane linear density and draft ratio on the physical and mechanical properties of core-spun cotton yarns"*, Journal of the Textile Institute, vol. 105, no. 7, pp. 753-759, 2014.

[2] F. Marsal, D. Palet , M. Riera , A. Serra, L. Indrie and M. Ratiu, *" New development in the core yarns manufacture",* Annals of the University of Oradea. Fascicle of Textiles, Leatherwork, vol. XI, no. 2, pp. 86-89, 2010.

[3] D. Duran and H. Kadoğlu, *"Electromagnetic shielding characterization of conductive woven fabrics produced with silver-containing yarns",* Textile Research Journal, vol. 85 (10), pp. 1009-1021, 2015.

[4] R. Perumalraj and B. S. Dasaradan, *"Electromagnetic shielding effectiveness of copper core yarn knitted fabrics",* Indian Journal of Fibre & Textile Research, vol. 34, pp. 149-154, 2009.

[5] A. Telli, Y. Daşan, O. Babaarslan and S. Karaduman, *"Usage of Core and Dual-Core Yarns Containing Tungsten for Electromagnetic Shielding",* Advance Research in Textile Engineering, vol. 2(1), pp. 1013-1019.

[6] O.G. Ertaş, B. Z. Ünal and N. Çelik, *"Analyzing the effect of the elastane-containing dual-core weft yarn density on the denim fabric performance properties* Journal of the Textile Institute, vol. 107, no. 1, pp. 116-126, 2016.

[7] A. Chakraborty and S. M. Chatterjee, *"Influence on controlled pretension on hairiness of silk-nylon core-spun yarns",* Indian Journal of Fibre & Textile Research, vol. 19, pp. 12-16, 1994.

[8] N Tarafder and S. M. Chatterjee, *"Physical and mechanical properties of cotton covered nylon core yarns",* Indian Journal of Fibre & Textile Research, vol. 15, pp. 113-119, 1990.

[9] A.A. Jeddi, M. S. Johari and A.A. Merati, *"Study of the structural and physical properties of cotton-covered nylon filament core-spun yarns",* Journal of the Textile Institute, vol. 88, no. 1, pp. 12-20, 2014.

[10] O. Babaarslan, *"Method of producing a polyester/viscose core-spun yarn containing spandex using a modified ring spinning frame ",* Textile Research Journal, vol. 1 (4), pp. 367-371, 2001.

[11] V. Viswarajasekaran and K. Raghunatan, *"An investigation on the physical properties of core yarns",* Indian Journal of Fibre & Textile Research, vol. 31, pp. 298-301, 2006.

[12] C. I. Su, M. C. Maa and H. Y. Yang, *"Structure and performance of elastic core-spun yarn",* Textile Research Journal, vol. 74 (7), pp. 607-6010, 2004.