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Investigation of Yarn Properties of Modified Yarn Spinning Systems with Air Nozzle Attachment

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Abstract

In the present study, conventional ring and compact spinning systems were modified with the air nozzle placed below the drafting system of the spinning frames. The modification of the conventional ring spinning system was called 'Jetring', while the combination of air nozzle and compact spinning system was named 'Compact-Jet'. Actually, in literature there is not this kind of system ,and thus the Compact-Jet spinning system is a new application in the spinning field. When the properties of ring, Jetring, compact and Compact-jet yarns were compared, it was determined that modified spinning systems contribute to an effective reduction in the number of long hair length groups as well as insignificant changes in twist and tensile properties. The reduction in s3 yarn hairiness values reaches up to 40% in the Jetring spinning system. However, the Compact-jet spinning system improves the hairiness of conventional ring spun yarns by over 50%. A relatively higher reduction in yarn hairiness is possible with proper changes in the nozzle geometry and air pressure level. Nevertheless, in comparison to the Jetring spinning system, the Compact-jet spinning system is very effective regarding yarn properties, particularly yarn hairiness. The system even increases the yarn tenacity slightly.

Key words: *yarn, hairiness, air nozzle, swirling airflow, tenacity, irregularity.*

Introduction

In the last few years, yarn hairiness has attracted increasing interest due to the importance of high production speeds and commercialisation of measurement instruments. On the other hand, the effect of yarn hairiness on textile processes, especially weaving and knitting, and its influence on the characteristics of the end-product has led to the introduction of the measurement of hairiness [1]. Therefore hairiness is taken as the parameter for evaluation of the quality of yarns.

In order to decrease yarn hairiness, new spinning systems and several modifications have been introduced to the textile sector. One of the new spinning methods is compact spinning based on the condensing of fibres with air current or the magnetic effect, and hence minimising the spinning triangle on the ring spinning frame. Compact spinning enables most of the fibres to be integrated into the yarn structure. Nowadays there have been attempts based on the placement of the nozzle component used in air-jet spinning system in the conventional ring spinning system, the process of which is called 'Jetring'. Jetring could be mentioned as one of the modified spinning systems, the objective of which is to bind the fibres projected onto the yarn body by means of the swirling airflow in the nozzle and hence produce less hairy yarns. Another application of the nozzle component is the Compact-jet spinning system, first introduced by Yılmaz and Usal [10] (***Figure 1***). In the Compact-jet system, the nozzle is mounted below the RoCoS compact unit.

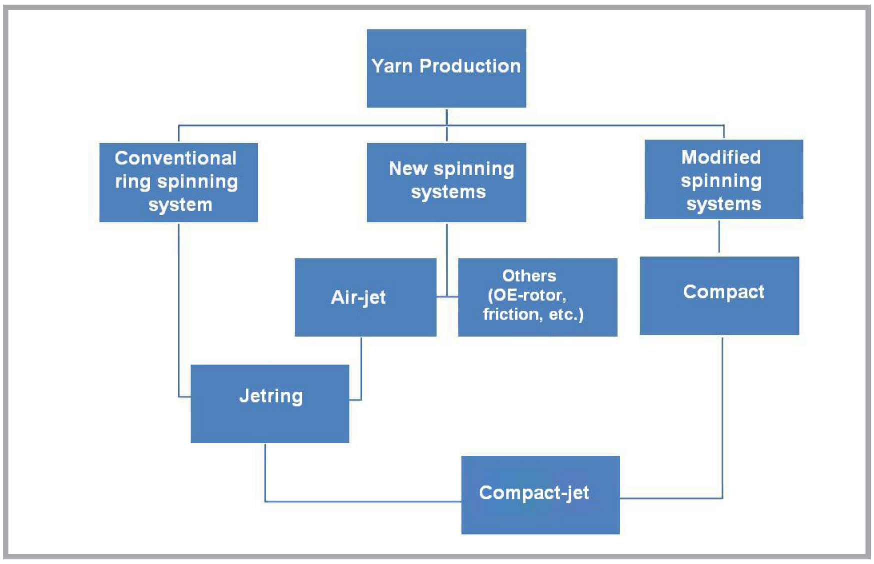

Figure 1. *Basic classification of the spinning systems Yılmaz and Usal [11].*

Table 1. *Fibre properties of Aegean cotton.*

Properties	Mean value
Staple Length, mm	30.25
Micronaire (Mic)	3.8
Uniformite Index (U.I.)	84.4
Tenacity, cN/tex	35.6
Elongation at break, %	4.2
Short Fibre Index (SFI)	4.6
Yellowness (+b)	8.4
Reflectance, Rd	75.8
Colour Grade (CG)	31-2
Spinning Count Index (SCI)	170

Table 2. *Spinning particulars.*

Parameters		Values
Roving linear density, tex		695
Linear density, tex		19.68
Twist, t.p.m		797
α_e		3.7
Mean spindle speed, r.p.m		10000
Take up speed, m/min		12.5
Traveller		SFB 2.8 PM udr
Traveller ISO No		31.5
Ring diameter, mm		36
Draft	Break draft	1.181
	Total	37.05

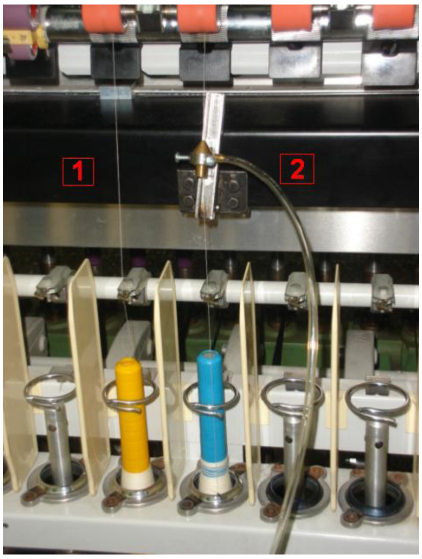

Figure 2. Conventional ring (1) and Jetring (2) spun yarn production on a Rieter G10 ring spinning machine.

Many researchers have indicated that Jetring yarns have lower hairiness compared to that of conventional ring spun yarns [2 - 6]. On the other hand, findings regarding the tensile properties of Jetring yarns do not agree with each other. Some researchers have indicated that the tensile properties of Jetring spun yarns are higher than conventional ring spun yarns [6, 7], while some of them have reported that conventional ring and Jetring have similar tenacity and elongation values [3, 5, 8, 9].

In literature, in the studies commonly focused on the analysis of air nozzle usage in the spinning process, different fibre types and yarn linear densities were used. However, there has been no effort to incorporate the compact spinning system and the nozzle. Therefore the Compact-jet spinning system can be considered to be a new application in the spinning field. It was reported that the system is effective regarding yarn hairiness [10, 11]. In the present study, it was aimed to compare the properties of Compact-jet yarns with those of Jetring yarns. Jetring and Compact-jet are modified spinning systems based on air nozzle usage. In particular, we focused on the comparison of the effect of both modified spinning systems on yarn hairiness as well as on the determination of changes in other properties of Jetring and Compact-jet yarns.

Material and method

Yarn production

To determine the effect of an air nozzle on yarn properties, we produced 100% combed cotton Jetring and Compact-jet yarns of 19.68 tex linear density (yarn count). And then conventional ring and compact yarns were obtained with the same rovings. Thus four different yarn types were spun with the same raw material. The roving linear density was selected as 695 tex and fibre properties are given in ***Table 1*** (see page 43).

During all the yarn productions, importance was given to working with the same spinning parameters, e.g. the same twist, draft, spindle speed and traveller type, etc. Spinning particulars are given in ***Table 2*** (see page 43).

Jetring yarn spinning system

In Jetring yarn production, a designed supporting device was first mounted on the spinning systems to enable nozzle usage. To combine the conventional ring and air nozzle, the nozzle was placed below the drafting system of a Rieter G10 conventional ring spinning machine (***Figure 2***).

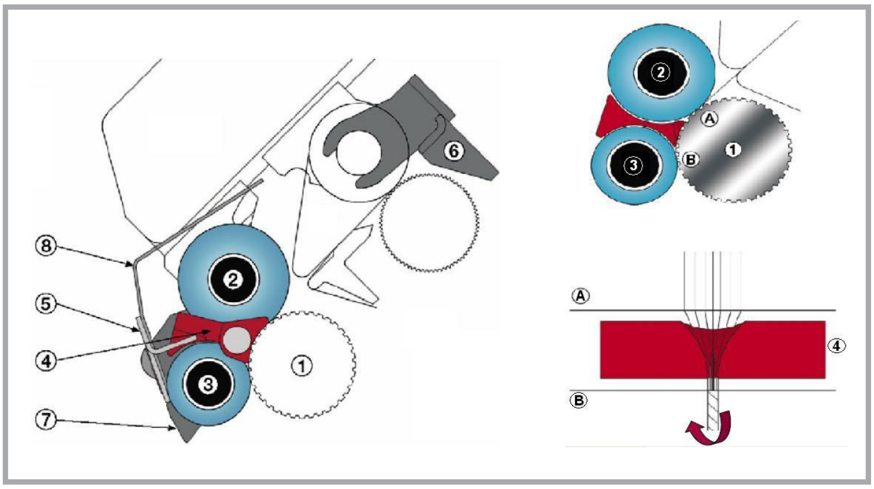

Figure 3. Main elements of RoCoS compact spinning system [13] (1: Bottom roller, 2: Front roller, 3: Delivery roller, 4: Compactor equipped with magnet, 5: Supporting bridge, 6: Roving guide, 7: Top roller holder, 8: Weighting spring).

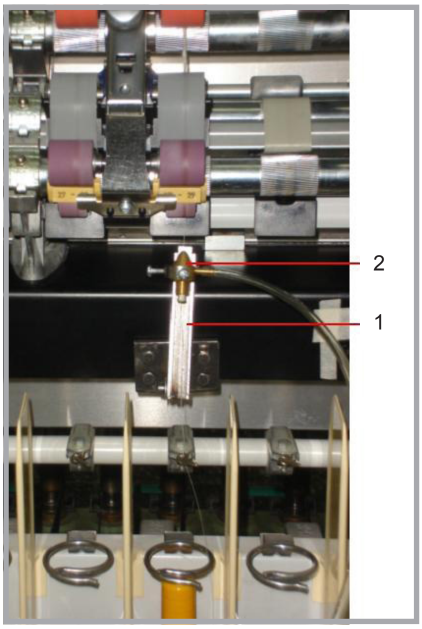

Figure 4. Application of air nozzle (2) in RoCoS compact spinning system using a supporting device (1).

The supporting device is optional with respect to adjusting the nozzle position and distance between the exit of the drafting unit and nozzle. The air nozzle was positioned about 6 cm below the delivery roller of the conventional ring spinning system.

Compact-jet yarn spinning system

The supporting device, used for Jetring yarn production, was placed on the RoCoS compact spinning system.

RoCoS is one of the compact spinning systems. As seen in ***Figure 3***, the bottom roller (1) supports the front roller (2) and delivery roller (3). The magnetic compactor, with a specially designed slit (4), lies between the front and delivery rollers. Thus a compression chamber generated through the bottom roller surface starts from clamping line A to B. The fibre strand is drafted above clamping line A, as it is in the conventional ring spinning system. Following clamping line A, the fibres are guided into the magnetic compactor slit and condensed throughout the magnetic compression chamber. When they pass clamping line B, twist coming from the ring and traveller is given to the fibres, and hence yarn is produced [12].

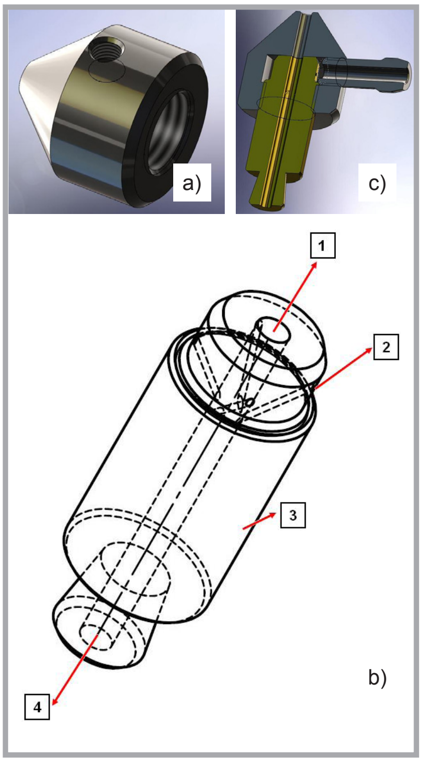

Figure 5. Nozzle head (a), nozzle body (b) and nozzle (c) (1: Nozzle inlet, 2: Injectors, 3: Twisting chamber, 4: Nozzle outlet).

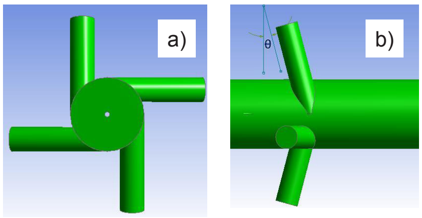

Figure 6. Nozzle injectors (a) and injector angle (b).

To combine the compact spinning system and air nozzle, the nozzle was positioned between the exit of the RoCoS compact unit and yarn guide, and then Compact-jet yarns were produced (***Figure 4***). The distance between the nozzle and drafting unit of the RoCoS system was about 6 cm, as in Jetring yarn production.

Air nozzle

The nozzle used in Jetring and Compact-jet yarn production consists of a nozzle head and body (***Figure 5***). The nozzle body has a cylindrical cross section consisting of a main hole (1), injectors (2), twisting chamber (3) and nozzle outlet (4) (***Figure 5.b***). The main hole starts from the nozzle inlet to nozzle outlet, and the nozzle has a constant diameter of 2.5 mm. Injectors are positioned at certain angles with respect to the nozzle axis, and thus they lie tangentially.

In present work, two types of nozzle were used to minimise variations in the results. The nozzles differ from each other regarding the injector angles. The axial angles of the injectors (θ) are 15º and 45° (***Figure 6***). Air enters at an angle of 15º and 45° to the main hole. The nozzle with 15º injector angle was named Nozzle-1, while the 45º was termed Nozzle-2. The nozzle head transfers pressurised air coming from the compressor into the nozzle body by means of the injectors. In both nozzle types, the same nozzle head was used. In Jetring and Compact-jet yarn production, the air pressure was kept at 75 kPa.

Yarn tests

To minimise any possible variation, we used the same spindles for each yarn type. Yarn tests were carried out on an Uster Tester 3, Zweigle G566, Uster Tensorapid and Officine Brustio ETT and the cops of each system were fed in the same order to the testers (***Table 3***). Three samples were tested for each yarn type. The tests were carried out under standard atmospheric conditions and we conditioned samples for min. 24 hours before the tests. All the tests were carried out on the same testers and the results analysed statistically to determine any significant differences.

Results and discussion

Yarn Appearances

Yarn appearances were analysed with scanning electron microscopy, and typical views are shown in ***Figure 7***.

As seen in the typical views, all the yarns analysed have similar appearances and there is no significant difference in the yarn structures. All yarns, to some extent, have projected fibres. However, conventional ring spun yarns seem more uneven compared with the other yarns.

On the other hand, Jetring and Compact-jet yarns spun with the nozzles also have similar structures. In these yarns, some of the surface fibres are wrapped on the yarn body (***Figure 9***). However, the wrapping cases of the fibres are not distributed regularly along the whole yarn length. In some part of the yarns, the wrapping cases are considerably intensive, while no wrappings could be observed in other parts. Nevertheless, in Compact-jet yarns more wrapping fibres were observed in comparison to the Jetring yarns.

Yarn hairiness results

Zweigle s3 results of the yarns are given in ***Figure 10***. Yarn hairiness is characterised by the s3 value in the Zweigle hairiness tester. The Zweigle s3 parameter is the total number of protruding hairs of 3 mm length or more in 100 m of yarn. As mentioned in the previous section, two types of nozzle were used, differing from each other regarding the injector angle. Nozzle-1 symbolises the nozzle with a 15° injector angle and Nozzle-2 that with a 45° injector angle.

According to ***Figure 9*** and ***Table 4***, the yarns produced with the nozzles have significantly lower s3 hairiness values than those produced without the nozzles. Jetring and Compact-jet spinning sys-

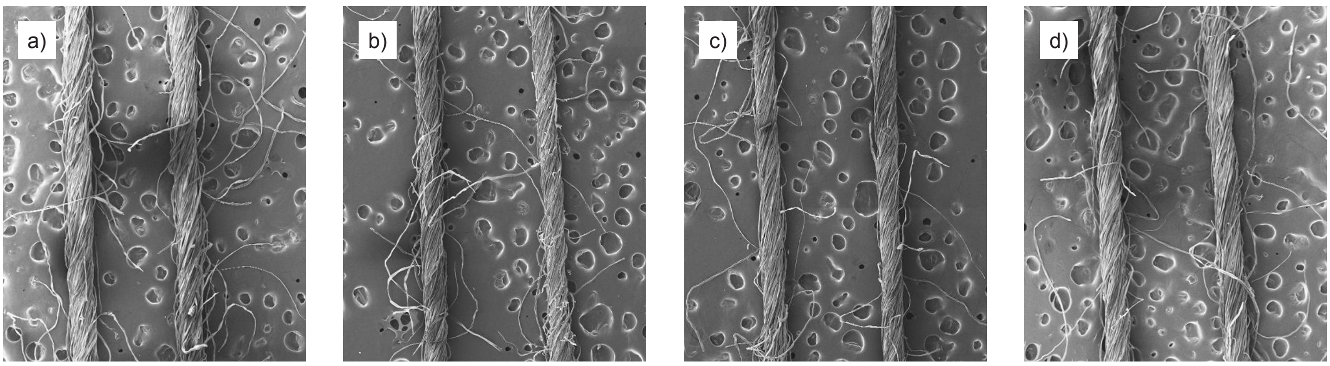

Figure 7. Fibres on a plain background (60x); a) Conventional ring spun yarns, b) Jetring yarns, c) Compact yarns, d) Compact-jet yarns.

Table 3. Test particulars for each yarn sample.

Yarn properties	Test device	Test length, m	Test number
Yarn irregularity and imperfections	Uster Tester 3	400	1
Yarn hairiness	Zweigle G566	100	3
Tensile properties	Uster Tensorapid	0.5	10
Yarn twist	Officine Brustio ETT	0.5	10

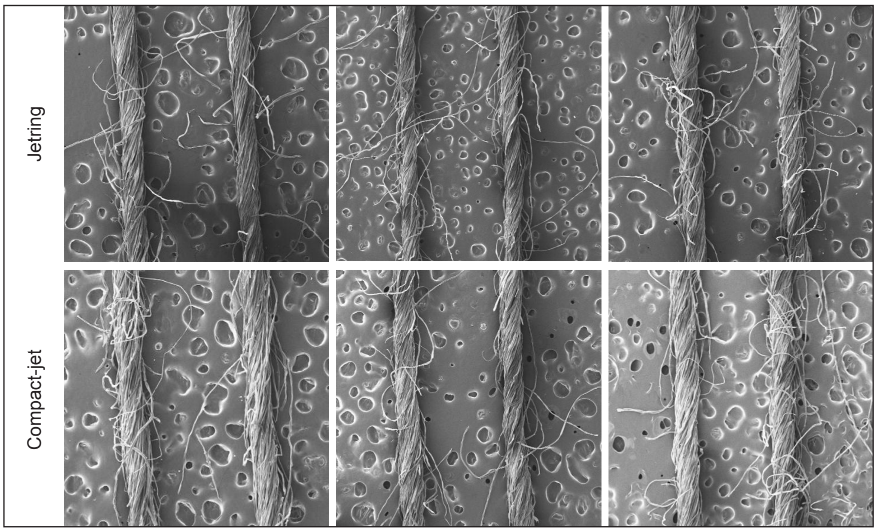

Figure 8. *Fibres on a plain background (60×).*

tems consisting of the nozzle component produce considerably less hairy yarns.

The Jetring modification of the conventional ring spinning system gives lower hairiness than the ring spinning system. This result coincides with literature [2 - 6]. On the other hand, the Compact-jet system, a combination of the compact spinning system and air nozzle, provides the least s3 hairiness values in comparison to the compact and even the other spinning systems analysed. In all yarns analysed, those produced on the ring spinning system have the highest s3 values. Regarding the nozzle types, as seen in ***Figure 9***, both nozzles give lower s3 values in the Jetring and Compact-jet spinning systems. There is not any statistically significant difference in the values of both nozzles (***Table 4***). Therefore both nozzle types produce less hairy yarns in the Jetring and Compact-jet spinning systems. On the other hand, as expected, compact yarns are significantly less hairy than conventional ring spun yarns.

Zweigle enables the user to sort the hairs into different length classes and thus evaluate the so-called short-hairiness (1 mm and 2 mm in length) and long-hairiness (3 mm or more) of a yarn [14]. In addition to the s3 results of the yarns, we also analysed the number of hairs in the 1 mm (s1) and 2 mm (s2) hair length groups, expressing short-hairiness. s1 and s2 values were summed, indicating the number of hairs in the 1 mm and 2 mm hair length groups.

According to these overall values, yarns produced with nozzles have higher short hairiness values than yarns spun on the spinning systems without nozzles (***Figure 10***). There is a statistically significant increase in the short-hairiness values of Jetring and Compact-jet yarns (***Table 4***). In the previous study, it was determined that Compact-jet yarns have lower short hairiness values than ring and compact spun yarns [10]. Therefore both results are not in agreement with each other. We believe that this results from the different nozzle types used in both studies, indicating that there is a significant reduction in long-hairiness values; although nozzle usage leads to different changes in short-hairiness depending on the nozzle type. In particular, Jetring yarns have the highest short hairs, while compact yarns have the lowest values.

In the air nozzle, a swirling airflow is produced depending on the nozzle geometry and pressurised air [8], with a false twist effect being created. It is believed that Jetring and Compact-jet yarns are first loosened to some extent due to swirling airflow or false untwisting which is in the opposite direction to the yarn twisting. And then they are tightened up again through the nozzle depending on the false twisting [2, 8]. In the research by Wang et al. and Cheng & Li, similar behaviour of pressurised air was observed in CFX simulations of the nozzles [15]. The untwisting and twisting case contributed to the wrapping of protruding hairs onto the yarn body, resulting in the reduction of long-hairiness values. On the other hand, swirling airflow does not generally cause any loss or additional twist in the yarn. Particularly, according to ***Figure 11***, twist values of yarns produced with a

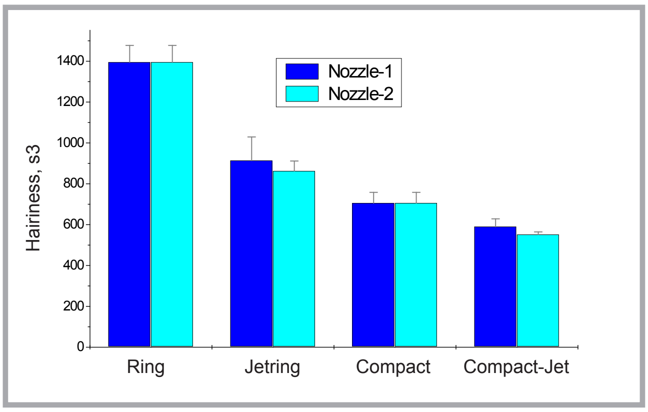

Figure 9. *Zweigle hairiness (s3) values of the yarns.*

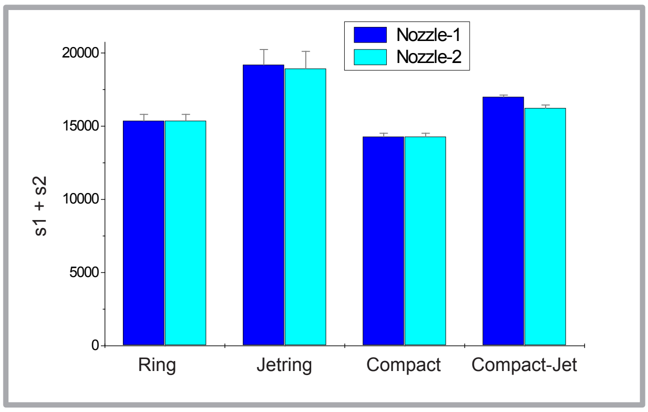

Figure 10. *Total number of hairs shorter than 3 mm.*

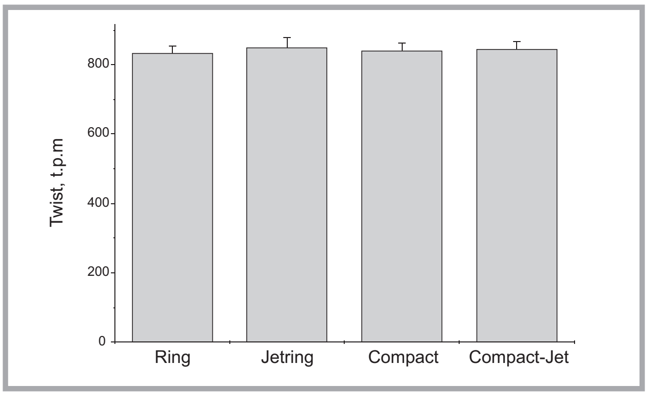

Figure 11. *Twist values of the yarns.*

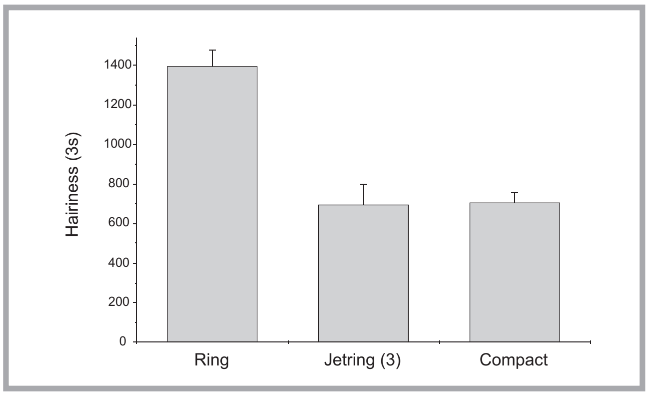

Figure 12. *Zweigle hairiness (s3) values.*

nozzle are similar to those of yarns produced without nozzles. There is not any significant difference in the twist values of all the yarns (***Table 5***).

Table 4. *Anova test results of yarn hairiness. * The mean difference is significant at the 0.05 level.*

Spinning Systems		s3	s1+s2
Ring	Jetring (1)	0.001*	0.021*
	Jetring (2)	0.000*	0.006*
Jetring (1)	Jetring (2)	0.507	0.316
Compact	Compact-jet (1)	0.010*	0.000*
	Compact-jet (2)	0.003*	0.000*
Compact-jet (1)	Compact-jet (2)	0.257	0.003*
Ring	Compact	0.000*	0.001*
	Compact-jet (1)	0.000*	0.000*
	Compact-jet (2)	0.000*	0.004*

Table 5. *Anova test results of yarn twist.*

Spinning Systems		Sig.
Ring	Jetring (1)	0.207
Compact	Compact-jet (1)	0.764

Long projected hairs are wrapped onto the yarn body in the Jetring and Compact-jet spinning systems. The effect of the swirling airflow changes depending on the nozzle type and sometimes long hairs cannot be wrapped with their whole length nor be completely locked into the yarn structure. This wrapping case causes long hairs to become short. Consequently the effect of the mechanism of the nozzle is to decrease the number of long hairs in terms of the wrapping onto the yarn body and, to some extent, convert some of the long hairs to short ones. This causes Jetring and Compact-jet yarns to have a higher number of short fibres in comparison to ring and compact spun yarns. As seen in ***Table 6***, swirling airflow in the nozzles of Jetring and Compact-jet systems causes an effective reduction in the number of long hair length groups. In particular, in length groups such as 15, 18, 21 and 25 mm, where there are not any long hairs.

The Jetring spinning system improves the hairiness of conventional ring spun yarns by up to 34 - 38%, while the Compact-jet spinning system enables a reduction in hairiness of up to 16 - 21% in comparison to compact yarns. Therefore both of the modified spinning systems, based on nozzle usage, are able to reduce yarn hairiness. The difference in hairiness of the Jetring and Compact-jet spinning systems is about 36%, with the latter leading to a higher reduction in yarn hairiness. In addition, Compact-jet yarns have lower s3 hairiness values by up to 60% compared with conventional ring spun yarns, the differences being statistically significant (***Table 4***). Therefore, in comparison to the Jetring spinning system, the Compact-jet spinning system is more effective with respect to yarn hairiness.

Additionally the hairiness of Jetring yarns is higher than that of compact yarns. However, when we realise some changes in the component of the Jetring spinning system, it is possible to get much lower hairiness values. In the present work, as shown in ***Figure 13*** (see page 48), the design of the nozzle head was changed and a spiral type nozzle head was used. The nozzle with a spiral head was called 'Nozzle-3', which is similar to Nozzle-1 and Nozzle-2. Its injector angle was 15°. In addition, the air pressure was increased from 75 to 100 kPa. As seen in ***Figure 12***, with the usage of Nozzle-3 and 100 kPa air pressure, the Jetring spinning system produces yarns with comparable s3 hairiness values to those of compact yarns. In addition, there are not any statistically significant differences in the hairiness results of the compact and Jetring yarns (***Table 7***). In this case, Jetring improves hairiness by up to 50%.

Consequently the Jetring and Compact-jet spinning systems are flexible and the reduction degree in hairiness can be increased in terms of changes in the air nozzle design and air pressure level.

Yarn tenacity

Tensile properties of the yarns were tested on an Uster Tensorapid, the tenacity results of which are shown in ***Figure 14***.

When the yarn tenacity results are analysed, two different trends are observed. Jetring yarns, based on the modification of the conventional ring spinning system, exhibit lower tenacity values compared with ring spun yarns. On the other hand, the Compact-jet spinning system, modification of the compact spinning system, produces higher yarn tenacity values than the compact and even other yarns.

Table 6. *Number of hairs in different hair length groups.*

Yarn type	Length groups, mm							
	1	2	3	4	6	8	10	12
Ring	15640	439	686	506	140	97	17	3
Jetring (1)	17432	675	564	259	41	25	4	0
Jetring (2)	18715	568	560	242	37	19	4	0
Compact	13358	673	494	171	18	8	1	0
Compact-jet (1)	16095	784	417	123	13	5	0	0
Compact-jet (2)	15404	840	432	106	11	0	0	0

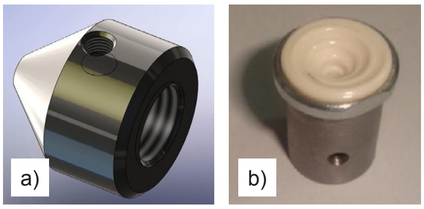

Figure 13. Conical (a) and spiral (b) type of nozzle heads.

The Jetring and Compact-jet spinning systems lead to different changes in yarn tenacity.

The differences in tenacity values of Jetring and ring spun yarns were found to be statistically insignificant (***Table 8***). Therefore both spinning systems produce similar tenacity values. However, for compact and Compact-jet yarns, statistically significance in the values changes depending on the nozzle type. In particular, the nozzle with a 15° injector angle produces significantly stronger Compact-jet yarns than compact yarns.

The Compact-jet spinning system enhances the tenacity of compact yarns slightly, with an increase of about 7 - 9%. Additionally Compact-jet yarns are also significantly stronger than ring spun yarns, and the Compact-jet system improves the tenacity of ring spun yarns by up to 16 - 17%.

As was mentioned in the yarn hairiness results, swirling airflow in the nozzle wraps the protruding hairs onto the yarn body and therefore more fibres are integrated into the Jetring and Compact-jet yarn structures. Due to the integration of the fibres with the wrapping cases, we expect to obtain higher tenacity values with the modified spinning systems. The Compact-jet system realised our expectations and stronger yarns were produced in terms of the wrapping case. In spite of the wrapping fibres in Jetring yarns, the yarn tenacity is lower than that of ring spun and other yarns. Contrary to the Compact-jet spinning system, the nozzle in the Jetring system causes a reduction in yarn tenacity values, the reason for which may be the distribution and character of the wrappings. In Jetring yarns, it was observed that the wrapping formation is not as intensive as in Compact-jet yarns, another reason for which may be the irregular wrapping formations. The untwisting and twisting effect of the airflow in the nozzle changes the yarn structure. Consequently the wrapping motion of the Jetring spinning system cannot be enough to produce stronger yarns compared with the ring and other yarns.

*Table 7. Anova test results of yarn hairiness; * The mean difference is significant at the 0.05 level.*

Spinning Systems		Sig.
Ring	Jetring (3)	0.000*
Ring	Compact	0.000*
Jetring (3)	Compact	0.912

*Table 8. Anova test results of yarn tenacity; * The mean difference is significant at the 0.05 level.*

Spinning Systems		Sig.
Ring	Jetring (1)	0.056
	Jetring (2)	0.067
Jetring (1)	Jetring (2)	0.795
Compact	Compact-jet (1)	0.023*
	Compact-jet (2)	0.060
Compact-jet (1)	Compact-jet (2)	0.610
Ring	Compact	0.070
	Compact-jet (1)	0.000*
	Compact-jet (2)	0.001*

Yarn elongation

Yarn elongation results for different yarns are given in ***Figure 15***.

In the yarn elongation results, there are no visible differences - all the yarns have similar yarn elongation values. In addition, according to ***Table 9***, there are no statistically significant differences in the values. Nevertheless, elongation values of Jetring yarns are slightly lower than those of ring spun yarns. For Compact-jet yarns, elongation properties change depending on the nozzle type.

Work of rupture property

In the present work, rupture properties of the yarns were analysed to better understand the tensile characters of the yarns. The work of rupture values of the yarns are shown in ***Figure 16*** and statistical analysis results are given in ***Table 10***.

The trend in work of rupture results is similar to that of the yarn tenacity. Ring spun yarns are stronger than the Jetring yarns obtained with the modified ring spinning system and more energy is required to break ring spun yarns (***Figure 17***). A similar case is observed for Compact-jet yarns. Compact-jet yarns are stronger than compact yarns and have higher work of rupture values. The difference in the values of ring and Jetring yarns was found statistically insignificant (***Table 10***). Also there are no statistically significant differences in the values of compact and Compact-jet yarns. In addition, Jetring yarns have the least values, while Compact-jet yarns require the most energy to break. Although differences in the values of ring and Compact-jet yarns reach up to 25 - 30%, there is no statistically significant difference.

Yarn Irregularity

Irregularity test results of the yarns are given in ***Figure 17***.

Both yarns types produced on the modified spinning systems have higher irregularity values. Jetring and Compact-jet yarns are more uneven than conventional ring and compact yarns. Nozzle usage increases the irregularity values of yarns spun on both spinning systems, with the amount of increase being similar. Higher yarn irregularity results of Jetring and Compact-jet yarns may be explained by the effect of wrapping fibres. The wrapping case causes the fibrous mass to accumulate in short lengths as well as changes in yarn thickness in related regions [2, 4, 5, 8, 10, 11, 16]. Yarn appearances shown in the present study indicate the fibres wrapped onto the yarn body with different characters.

Table 9. Anova test results of yarn elongation.

Spinning Systems		Sig.
Ring	Jetring (1)	0.882
	Jetring (2)	0.252
Jetring (1)	Jetring (2)	0.377
Compact	Compact-jet (1)	0.714
	Compact-jet (2)	0.871
Compact-jet (1)	Compact-jet (2)	0.598
Ring	Compact	0.636
	Compact-jet (1)	0.720
	Compact-jet (2)	0.375

Table 10. Anova test results for work of rupture .

Spinning Systems		Sig.
Ring	Jetring (1)	0.489
	Jetring (2)	0.596
Jetring (1)	Jetring (2)	0.236
Compact	Compact-jet (1)	0.244
	Compact-jet (2)	0.244
Compact-jet (1)	Compact-jet (2)	1.000
Ring	Compact	0.263
	Compact-jet (1)	0.057
	Compact-jet (2)	0.057

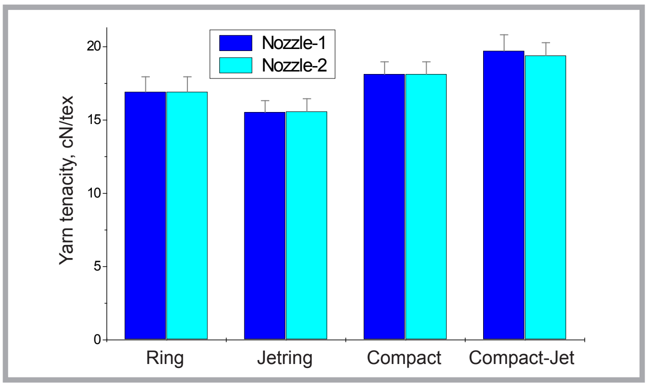

Figure 14. Yarn tenacity results of the yarns.

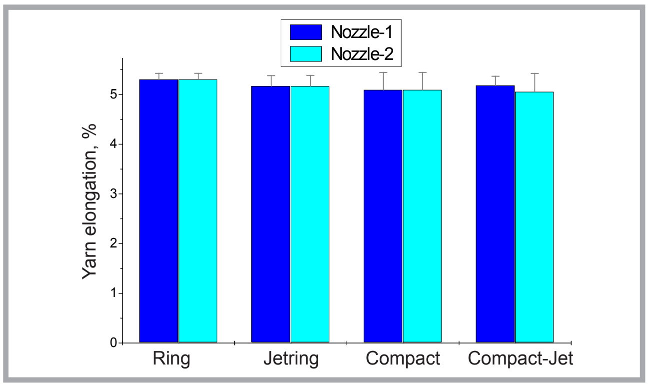

Figure 15. Yarn elongation results of the yarns.

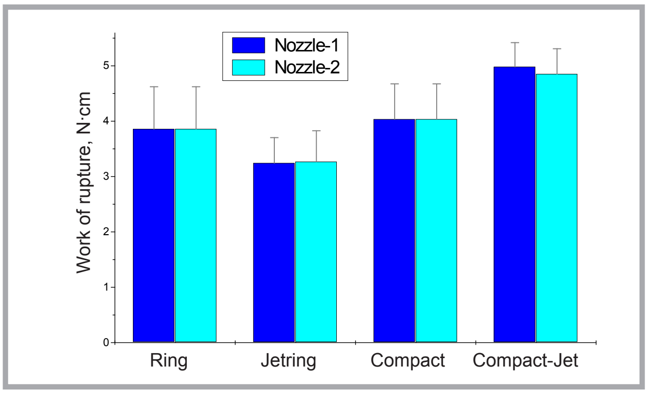

Figure 16. Work of rupture results for different yarns.

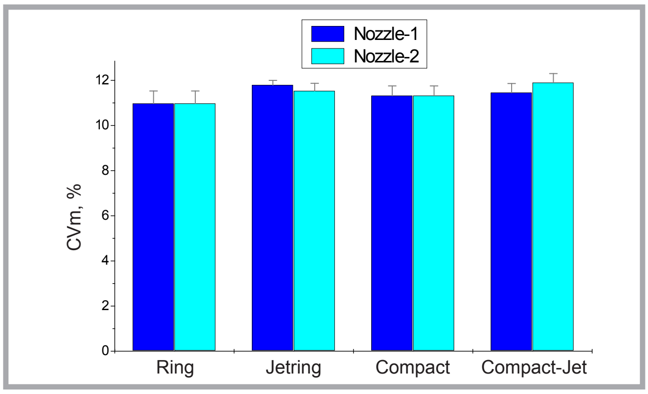

Figure 17. Yarn irregularity results of the yarns.

Conclusions

This study compares the properties of yarns produced on Jetring and Compact-jet spinning systems. Jetring and Compact-Jet are modified spinning systems based on the attachment of an air nozzle below the front drafting rollers of the spinning frame. Particularly, Compact-jet is a new application as there is such system in existence. The following conclusions can be drawn from the study:

- Ring, Jetring, compact and Compact-jet yarns have similar yarn appearances. However, in Jetring and Compact-jet yarns, some of the hairs projected are wrapped over the yarn body by the airflow in the nozzle. Therefore Jetring and Compact-jet yarns have significantly lower s3 hairiness values than ring and compact yarns. Particularly, for Compact-jet yarns, more wrapping fibres were observed along the whole yarn length. Hence Compact-jet yarns are the least hairy yarns, while conventional ring spun yarns have the highest number of long hairs.
- There are no regularly distributed and completely locked wrapping cases. Therefore, to some extent, long hairs in Jetring and Compact-jet yarns become shorter and, contrary to long hairiness, their number increases. Hairiness results indicate that the nozzle component in Jetring and Compact-jet systems mainly contribute to the effective reduction in the number of long hair length groups.
- As for the tensile properties of the yarns, there are no statistically significant differences in the tenacity values of all yarns. However, Compact-jet, modification of the compact spinning system, produces stronger yarns than the compact and even other yarns. Contrary to Compact-jet yarns, Jetring yarns exhibit lower tenacity values than the other yarns. The lower tenacity results of Jetring yarns may result from the irregular wrapping character and distribution intensity of wrapping fibres. On the other hand, regarding the yarn elongation results, there are no significant differences in all yarns.
- An interesting change was observed in yarn irregularity results. The wrapping case particularly accumulated fibrous mass in short lengths, and hence there was a variation in yarn thickness, leading to Jetring and Compact-jet yarns with higher yarn irregularity values.
- In this study, Jetring and Compact-jet yarn production was realised with two different nozzle types. Nevertheless, the nozzles lead to similar changes in yarn properties, but the degree of their impact changes. Therefore nozzle geometry has a greater effect on yarn properties. With these types of nozzles, the Jetring spinning system improves the hairiness of conventional ring spun yarns by up to 34-38%, while the Compact-jet spinning system enables a reduction of up to 16-21% in comparison to compact yarns. The difference in hairiness of Jetring and Compact-jet yarns is about 36%, therefore the Compact-jet spinning system is more effective than the Jetring spinning system. However, the Jetring spinning system can be capable of producing yarns of comparable s3 hairiness values with those of compact yarns when the structural parameters of the nozzle or yarn pressure are changed. In this case, the reduction in yarn hairiness increases in the Jetring spinning system.

Consequently, the Jetring and Compact-jet spinning systems produce less hairy yarns of wrapping fibres and the systems predominantly reduce the number of longer hairs with no negative effect on the other yarn properties. In particular, the Compact-jet spinning system, compared with the Jetring spinning system, is more effective in terms of yarn properties. On the other hand, the Jetring and Compact-jet spinning systems have the possibility for further improvement in terms of changes in nozzle geometry and air pressure level.

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