(REFEREED RESEARCH)

LINT GENERATION: THE EFFECTS OF YARN PRODUCTION SYSTEMS

DÖKÜNTÜ OLUŞUMU: İPLİK ÜRETİM SİSTEMLERİNİN ETKİSİ

Gamze Süpüren MENGÜÇ[1], Gonca Özçelik KAYSERİ[1],*Nilgün ÖZDİL[2]

[1]*Ege University Emel Akın Vocational High School, İzmir, Turkey*
[2]*Ege University Department of Textile Engineering, İzmir, Turkey*

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ABSTRACT

Lint generation, which is occurred due to the yarn to yarn friction during the subsequent processing of the yarns is one of the yarn properties causing several problems such as fiber loss, decreasing in yarn strength, problems in machines and working environment during fabric production and showing itself as faults on fabrics. As a result of all, it causes decreasing in the production productivity. In this study, it was aimed to define the lint generation characteristics of the yarns produced by different production systems (ring, compact, rotor, RoCoS compact, siro). Lint generation tendencies of these yarns were tested by using CTT (Constant Tension Transport) instrument. Besides, the effects of the production systems, the influence of the winding process on lint shedding feature and the correlation between the yarn hairiness and lint generation was statistically investigated.

Keywords: Lint generation, Yarn hairiness, Winding, Cotton yarn, Ring, Rotor, Compact, Siro, RoCoS compact, Spinning

ÖZET

İpliğin sonraki işlemleri sırasında, iplik-iplik sürtünmesi nedeniyle oluşan döküntü oluşumu, lif kaybına, iplik mukavemetinde azalmaya, kumaş üretimi sırasında makine ve çalışma ortamında problemler yaşanmasına yol açmakta ve kendini kumaş üzerinde hatalar şeklinde göstermektedir. Bütün bunların sonucunda, üretim verimliliğinde azalmaya neden olmaktadır. Bu çalışmada, farklı üretim sistemlerinde (ring, kompakt, rotor, RoCoS kompakt, siro) üretilen ipliklerin döküntü oluşturma özelliklerinin incelenmesi amaçlanmıştır. Bu ipliklerin döküntü oluşturma eğilimleri CTT cihazı ile test edilmiştir. Üretim sistemlerinin etkisi yanında, bobinleme işleminin döküntü oluşumuna etkisi incelenmiş ve iplik tüylülüğü ve döküntü oluşumu arasındaki ilişki istatistiksel olarak tespit edilmiştir.

Anahtar Kelimeler: Döküntü oluşumu, İplik tüylülüğü, Bobinleme, Pamuk ipliği, Ring, Rotor, Kompakt, Siro, RoCoS kompakt, Eğirme

Corresponding Author: Nilgün Özdil, nilgun.ozdil@ege.edu.tr

INTRODUCTION

In current competitive manufacturing industry, production speeds of the machinery increase markedly. In textile industry, especially in knitting production, large quantities of knitted goods are produced at very high speeds due to improved machine technology.

The tendency of a yarn to shed fly or lint during knitting or other mechanical processes is known as lint shedding propensity (LSP). As the production speed of knitting machinery increases, lint becomes a major cause to lead to serious process troubles especially in case of cotton spun yarn. In particular, as yarn come into contact with many elements in the knitting machine and as knitting speed increases, lint generation also increased. Around 25% of all the faults occurring during the knitting process can be traced back to the incidence of lint/fiber fly. This presents many potential problems such as fiber loss, waste, lower working efficiency and higher environmental costs, etc., for the knitting industry, even it appears as defects on the fabric [1,2,3].

The study of fly generation during manufacturing has attracted the attention of many workers for decades and getting more attention because of the legal regulations requiring a clean working environment for employees since persons exposed to cotton dust particles during processing of textile fibers may develop a series of acute and chronic symptoms, commonly referred to as bysinosis [4-7].

According to the results of the studies on lint generation, it is revealed that fiber properties of the yarn and processing parameters in the production of fabric are the causes; however the main reason is friction between yarns and knitting or weaving elements that occurs where the moving yam passes over machine parts. Among all fiber properties, the fiber length has the greatest effect on the amount of fly generation. The correlations between the lint amount and Zweigle and Uster hairiness parameters were also determined. The higher lint factor values of the yarns in higher diameter arise from the hairy and coarser yarn structure. The knitting tension of the yam, yarn moisture content, weaving pattern, fabric speed and input tension, and the number of rollers on the machine have a significant effect on the fly generation [1-11].

The fiber fly problem seems to be a difficult problem to be solved but the textile machinery producers are trying to reduce the fiber fly generation as much as they can by adapting new technologies, which reduce the amount of stress and friction introduced into the yarns during production. The spun yarns produced by various spinning technologies differ significantly from each other in their surface characteristic and this difference is likely to be reverberated in their frictional behavior [5,10].

As a predominant commercial system for staple yarn formation, ring spinning has been able to supplant almost all other conventional spinning methods. Researchers have paid much attention to improve the quality of ring spun yarns rather than to produce super fine yarns, and thus many novel and effective spinning technologies have appeared, such as compact spinning, siro-spinning, solo-spinning, RoCoS etc [12].

Compact spinning is one of the most important improvements in traditional ring spinning, which is implemented by adding a fiber condensing device on a ring spinning frame to condense the fiber bundle and decrease or even eliminate spinning triangles. RoCoS is a spinning system introduced as a second generation of compact spinning system by Rotorcraft firm having a new concept in the compact spinning system field due to its different condensing principle. Siro-spinning is another most widely used new spinning methods. It is conducted on a conventional ring frame by simultaneously feeding two rovings into the apron zone at a predetermined separation [13,14].

Das et.al, investigated the characteristics of compact and conventional ring carded yarns under dynamic state. According to the test results, the lint generating tendency of the compact yarns was found less than the conventional yarns. Ute investigated the lint generation of the ring, compact, compact-siro and sirospun yarns and found that compact siro yarns generated minimum lint whereas ring spun yarns generated the maximum lint due to yarn hairiness, besides, as the yarn became finer, lint generation decreased in relation to the decrease in yarn diameter, yarn hairiness and frictional area [15,16].

Süpüren et.al, studied on lint generation properties of different carpet yarns. They investigated the effect of the fiber material, yarn count and twist factor to the amount of the lint [11]. Coll-Tortosa and Marcelo stated relationship between yam hairiness and the lint produced during knitting and determined the correlations between the lint amount and Zweigle and Uster hairiness parameters [17]. Koo applied wax finish to the cotton yarn to investigate the frictional properties and lint contamination during the knitting process. It was found that, the wax finish decreased the frictional forces of the yarn in comparison with the un-waxed yarn. But, lint contamination increased due to wax particles [18].

Telli and Özdil searched the effect of the r-PET fibers on the lint generation caused by yarn to yarn friction during process. Cotton and PES fibers, blended with r-PET fibers in different ratios were spun as 9 different yarns in ring spinning system in Ne 20 linear density and then the lint generation properties of the yarns were measured by using by CTT. They found that as the amount of r-PET fibers increased, the lint generation of the yarns increased [19].

Although, there have been several studies on the comparison of the quality characteristics of the yarns produced in these spinning systems, a few studies on the lint generation characteristics are exist. Therefore, in this study, different types of yarns were produced by diverse spinning systems (ring, open-end, RoCoS, siro, compact) and in order to determine the differences among the lint generation characteristics of these yarns, all produced yarns were tested by CTT (Constant Tension Transport) instrument. In order to define the effect of the winding process on the lint generation, the yarns were tested before and after winding in cop and cone forms and also the relationship between yarn hairiness and lint factors of the yarns were investigated.

MATERIALS AND METHODS

In this study, for the production of the ring, RoCoS compact, siro and compact yarns, 100% cotton rovings in Ne 0.8 produced in carded and combed system were used, for the open-end yarns, draw frame sliver in 5,4 ktex (Ne 0.11) was used. The fiber specifications are given in Table 1.

The production conditions of the yarns are given in Table 2. All yarns were produced in 20 tex and in the same yarn twist coefficient (α_{tex}=3445, 770 T/m). Comber noil for the combed yarns was adjusted as 15 %. Totally nine different yarns were produced such as ring carded, ring combed, compact carded, compact combed, RoCoS carded, RoCoS combed, siro carded, siro combed and open-end yarns. The cones were produced by using Schlafhorst winding machine in 500 m/min speed.

The amount of the lint generation of these yarns was measured with CTT Lint tester (Fig.1a,1b). The apparatus mounting on CTT instrument measures the amount of the lint generated during one km long while the yarn is running under constant tension at a certain test speed. During lint test, the yarn is wrapped around itself. As the yarn is moving, the generated lint is collected on a filter paper under the vacuum sealed enclosure (Fig.1c). The test automatically ends when one km of yarn is passed. The amount of lint generated is expressed as mg/km. In the study, the test speed was adjusted as 100 m/min and test length was 1000 m for all yarns, according to the suggested test procedure of the producer company. The tensions of the yarns were adjusted according to formula given below [20,21].

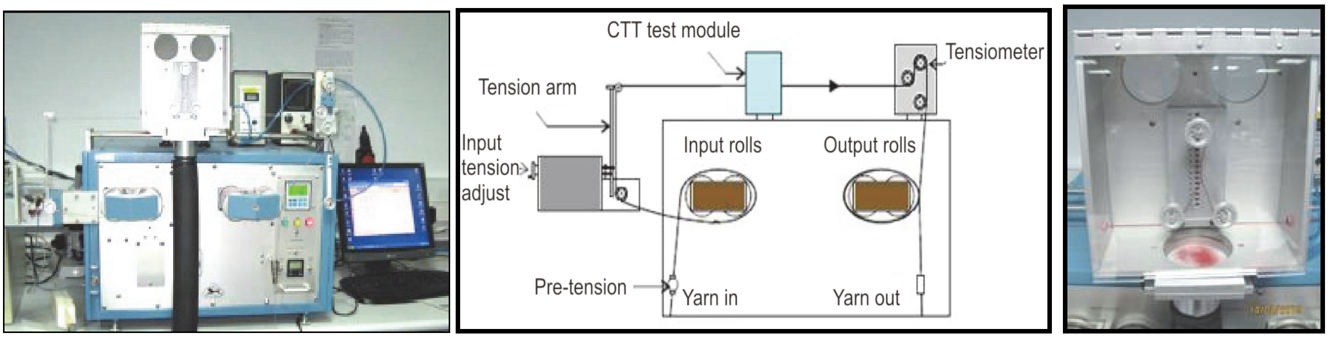
Yarn tension (cN) = 301.58/yarn linear density (Ne)

Table 1. Basic specifications of the cotton fiber used in the study

Fiber fineness (mic.index)	Fiber length (mm)	Fiber strength (g/tex)	Fiber elongation (%)
4.83	30.09	32.2	7.9

Table 2. Yarn production parameters

Yarn type	Yarn spinning machine	Speed (rpm)	Diameter of the ring (mm)
Ring	Pinter Merlin	10.000	40
Compact	Rieter Compact K45	10.000	40
RoCoS	Rieter G30	10.000	42
Siro	Rieter G30	10.000	42
Open-end	Rieter R40	90.000	33 (rotor diameter)



(a) **(b)** **(c)**

Figure 1. a) CTT Lint Tester, b) the path of the yarn on CTT (c) collection of the lint on the filter [20,21]

Yarn hairiness and yarn unevenness tests were carried out by Uster Tester 5 S800 instrument according to ISO 16549 with the measurement speed of 400 m/min and measurement length of 1000 m.

The effect of the yarn production methods on the hairiness and lint generation characteristics of the yarns were evaluated statistically. Besides, in order to determine the changes in these properties caused by winding process, independent samples student-t test was carried out with the results of the yarns in cop and cone forms.

RESULTS AND DISCUSSION

Although all yarns were produced in the same yarn count and twist values, their actual count and twist values were also measured as given in Table 3.

Yarn lint factor and hairiness results were determined for yarns both in cop and cone forms are given in Table 4, Figure 2 and Figure 4.

Table 3. Yarn count and yarn twist results

	Yarn Count		Yarn Twist	
	Yarn count (Tex)	Yarn count CV (%)	Twist (T/m)	Twist CV (%)
Ring combed	20.1	1.5	790	1.93
Ring carded	19.9	1.2	808	1.82
Compact combed	19.5	1.2	779	2.56
Compact carded	19.8	1.3	777	3.41
RoCoS combed	19.6	1.2	775	2.26
RoCoS carded	20.1	1.0	772	2.66
Siro combed	19.6	1.1	758	2.41
Siro carded	19.1	1.2	757	1.12
Open-end	20.1	1.1	-	-

Table 4. Yarn hairiness and lint factor values of the yarns

	Lint factor (mg/km)		Hairiness (H)	
	In cop form (mg/km)	In cone form (mg/km)	In cop form	In cone form
Ring combed	42.14	26.05	6.17	6.92
Ring carded	55.96	26.60	7.09	7.44
Compact combed	16.94	13.54	4.80	5.03
Compact carded	29.14	23.10	5.09	5.67
RoCoS combed	9.88	8.38	4.15	4.32
RoCoS carded	18.70	15.80	4.53	4.87
Siro combed	10.44	7.54	5.03	5.21
Siro carded	17.52	10.78	5.70	5.93
Open-end	-	8.12	-	4.23

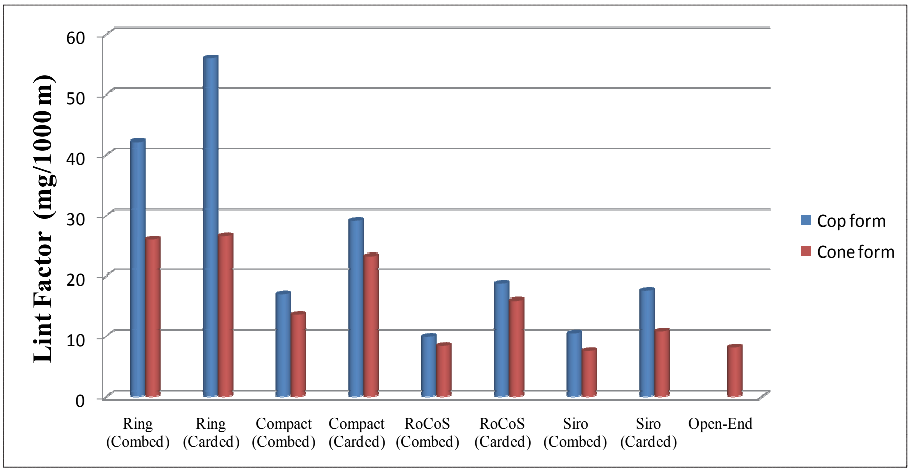


Figure 2. Lint factor values of the yarns based on yarn production methods

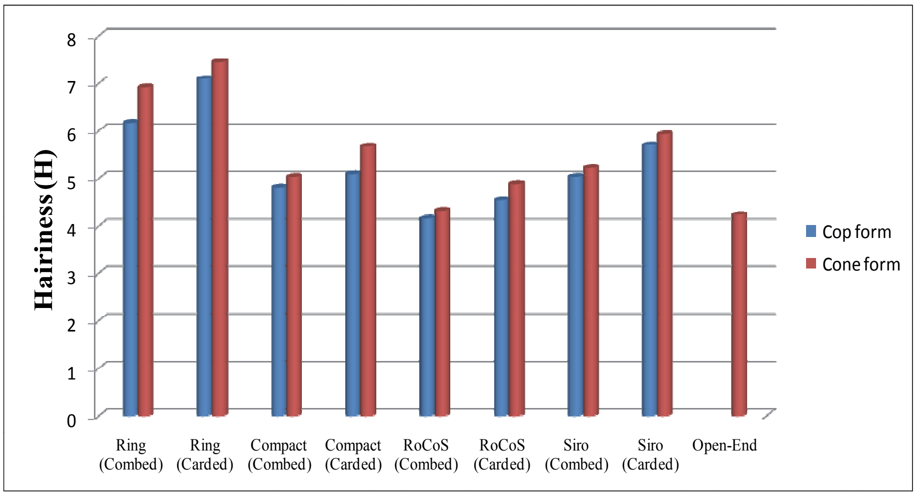


Figure 3. USTER hairiness (H) of the yarns based on yarn production methods

In order to compare lint generation characteristics of the yarns with each other statistically, multiple comparison statistical test (Student Newman Keuls-SNK) was carried out and the means for groups in homogenous subsets are displayed in Table 5 and Table 6. As open end yarns were produced directly in cone form and winding process was not used, the results of these yarns were evaluated in the group of cop yarns. According to the results, 9 different yarn types in both cops and cones were divided into 4 groups based on the mean lint factor values, which meant that 95% confidence limits of each group did not overlap and the differences between the mean values were statistically significant.

According to the results, the combed yarns had lower lint amount compared to the carded yarns due to high longer fiber content and as a result of that had lower hairiness. As it can be seen from Fig. 2, the highest lint generation occurred by ring yarns in both cop and cone forms of the yarns. RoCoS and siro yarns had relatively same tendency in terms of lint factor. Although RoCoS spinning system is a second generation of compact system, it seems better in fluff formation. Due to the long cotton fibers inside the yarn structures and having condensed composition of RoCoS and compact combed yarns, the hairiness of the yarns are relatively low causing less lint formation. Siro yarns are twisted by using two separate rovings together and this system results in lower hairiness compared to ring yarns. Among all yarns, open-end yarn produced lowest lint during test period due to the wrapped fibers in transverse direction of the open-end yarn structure. Generally, in both cop and cone forms, yarn hairiness values are seen to be parallel with the amount of lint factor values of the yarns. Therefore, the parameters affecting yarn hairiness such as yarn spinning system, fiber length, fiber fineness, spinning triangle geometry could be important in lint generation characteristics of the yarns as well.

Table 5. Multiple comparison result for yarn lint factor values in cop forms

Yarn type	N	Subsets			
		1	2	3	4
Open-end	5	8,12			
RoCoS combed	5	9,88			
Siro combed	5	10,44			
Compact combed	5	16,94			
Siro carded	5	17,52			
RoCoS carded	5	18,70			
Compact carded	5		29,14		
Ring combed	5			42,14	
Ring carded	5				55,96
Sig.		0,255	1,000	1,000	1,000

Table 6. Multiple comparison result for yarn lint factor values in cone forms

Yarn type		Subsets			
		1	2	3	4
RoCoS combed	5	7,54			
Siro combed	5	8,38			
Compact combed	5	10,78	10,78		
Siro carded	5		13,54	13,54	
RoCoS carded	5			15,80	
Compact carded	5				24,66
Ring combed	5				26,05
Ring carded	5				26,60
Sig.		0,116	0,090	0,162	0,445

As given in Table 5 and Table 6, ranking of the yarns in terms of lint factor values were similar in both cop and cone forms. There were obvious differences among the values of compact carded, ring carded and ring combed yarns in cop forms whereas after winding process, these yarns had similar lint generation tendencies. After winding process, the reduction of lint factor values in carded yarns was approximately 31.73%, however in combed yarns 25.3% reduction occurred. In cop form, the lint factor values were higher compared to the values of cones, which is due to the lost fibers during winding process. It is related with the existence of higher amount of shorter fibers in cone form of the yarns and removing of these short protruding fibers from the yarn structure during winding.

In order to determine the decrease in the number of short fiber ends that cause higher lint, in yarn structure, yarn cops and cones were also tested with CTT instrument for their yarn hairiness values. According to the classification of the instrument, it was found that number of short hairs of yarns in cone form is around 50% lower than yarn in cops form.

The differences between the lint factor values in cops and cones were evaluated statistically as well and p values calculated by the independent samples t-test are given in Table 7. It was found that the difference between the lint factor values in cops and cones forms were statistically significant except RoCoS carded, RoCoS combed and compact carded yarns.

Table 7. p values of the independent samples t-test between lint factor values of cops and cones

Yarn types	Lint factor values of the yarns in cops and cones forms (p-values)
RoCoS combed	0.118
Siro combed	0.049*
Compact combed	0.025*
Siro carded	0.000*
RoCoS carded	0.060
Compact carded	0.139
Ring combed	0.008*
Ring carded	0.014*
*Statistically significant according to α=0.05 significant level	

In order to determine the relation between the lint generation and hairiness of the yarns, Pearson correlation analysis was carried out. In cop form, as expected the correlation coefficient was higher (r^2=0.898 (p=0.001)) compared to the correlation coefficient calculated from the results of the yarns in cone form (r^2=0.761 (p=0.028)). Both coefficients are quite high and statistically significant. In order to indicate the relationship, scatter plots of yarn hairiness versus lint factor was plotted and linear regression coefficient values was determined as given in Fig.4. Similar to the correlation coefficient analysis, the regression coefficient calculated for the yarns in cop form (R^2=0.806) is higher than the coefficient of the yarns in cone form (R^2=0.579). Accordingly, especially for yarns in cop form, it is possible to calculate the lint factor of the yarns from USTER Hairiness (H) values by the linear regression curve determined via least square method. Therefore it can be stated that yarn hairiness can be an apparent indicator of how much the yarn will produce lint during the subsequent processes.

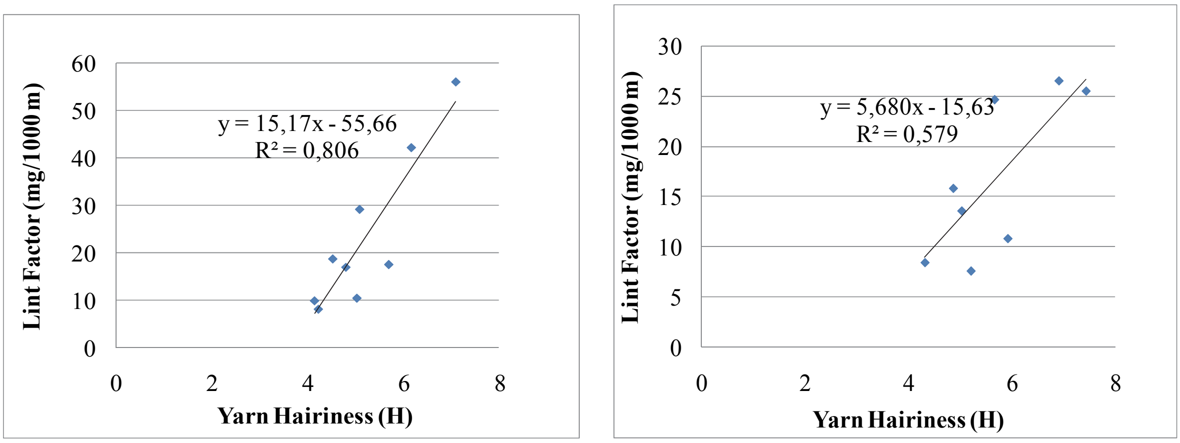


Figure 4. Scatter plots of the yarn hairiness versus lint factor (a) cop form (b) cone form

CONCLUSION

In this study, the lint forming properties of the yarns produced at different spinning systems were examined. For this purpose, 100% cotton carded and combed, ring, compact, RoCoS, siro and open-end yarns in 20 tex yarn linear density were produced and lint factor values of the yarns were measured by Lawson-Hemphill CTT (Constant Tension Transporter) instrument. According to the results, the following conclusions can be derived:

- Yarn spinning system has an obvious effect on lint formation. The maximum amount of lint generation among all spinning systems occurred in ring carded spinning. The least amount of lint was produced by open-end yarns and after open-end yarn, RoCoS, siro, compact combed yarns have lower lint factor values respectively.
- Since carded yarns contain more short fibers compared to combed yarns and consequently have higher hairiness, yarns produced from carded rovings have higher lint generation compared to the yarns produced from combed roving for all spinning systems.
- Yarn hairiness has a significant impact on the lint formation and the correlation between yarn hairiness and lint factor is found relatively high, especially for the results of the yarns in cop form.
- It was observed that winding process has a positive effect on lint forming since the short fibers are removed during yarn winding from cop to cone and also splicing of the yarns in faulty parts results in improved unevenness. The reduction in the occurrence of lint (31.73%) in the carded yarns after winding is greater than combed yarns (25.30%) since carded yarns contain shorter fibers.

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