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RESEARCH ARTICLE

Yarn quality investigation of compact cotton yarns with different combing noil percentage

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Abstract

The noil percentage of the combing process can be varied 8-25% depending on the cotton quality and combing machine adjustments to obtain desired cotton yarn quality parameters. In this study, the effect of combing noil percentage on yarn quality for different linear densities (19.7 and 14.8 tex) and twist coefficients (3, 3.5 and 4) in the production of the compact spun yarn was investigated. Comber noil percentage was chosen in accordance with optimum combing machine setting as 14, 16 and 18%. The amount of noil percentage to be extracted at comber was achieved by forward feeding detaching which means the material is fed whilst the nipper is rocking towards the detaching roller to obtain better fiber control. Then, the tenacity, elongation, unevenness, imperfection index (IPI) and hairiness values of the yarn samples were determined. Analysis of variance and multiple regression analysis was carried out to analyze the relationship between a yarn quality variables and linear density, twist coefficient, noil percentage independent variables.

1. Introduction

Short staple yarn production can be achieved by means of different systems such as ring, siro/solo, compact, open-end, vortex etc. Fundamentally, a short staple yarn production process starts with blowroom and carding, combing (optional), drawing, and roving processes can be achieved according to the yarn spinning system. In each of part of the processes, the foreign materials, dust, dirt, and short fibers in the raw material are cleaned at a certain rate. One of the important parameters that influence the yarn quality is the short staple length and average length of the staple fiber [1, 2]. It is necessary to remove the short fibers within the yarn spinnability limits before the spinning process. A large amount of short fiber sieving occurs especially in the combing process for producing high-quality yarn. The main purpose of yarn production is to obtain optimum yarn quality with the least elimination of the short fiber.

In literature, there are some researches about noil amount on yarn quality. Messiry et.al investigated the effect of the noil percentage on the structure parameters of compact and plies yarn. The percentage of noil percentage was varied between 13% and 20 % in the combing process. They manufactured compact spun yarns at different yarn counts and plied these yarns. Yarn properties were determined and they concluded that increasing noil percentage affect tenacity and elongation of single compact yarn positively. This situation observed yarn hairiness and unevenness properties of single compact yarn. They also observed the similar results for plied yarns [3]. Jamir and Mahmood studied about the effect of the comber noil percentage on yarn strength and yarn unevenness. They stated that noil at different proportions influenced yarn strength and unevenness statistically [4]. Dipali et.al investigated comber noil percentage on ring spun yarn quality. Ring spun yarns with two different yarn linear density (16.87 and 14.76 tex) at three different comber noil percentage (18, 20 and 22%) were produced. They found that ring spun yarn properties improved by increasing noil percentage for both yarn linear densities [5]. Bedez Ute et.al studied on the use of waste of yarn spinning mill and recycled cotton fiber from fabric waste blended at different blend ratio (10, 30 and 50%) with virgin cotton fiber to produce open-end spun yarns at Ne 20/1 yarn count. They categorized the cotton waste type as blowroom, card, sliver and fabric and compared with virgin cotton. Single jerseys knitted fabrics were also produced from these yarns. Yarns and knitted fabrics performance tests were carried out. They determined that dirty waste type (blowroom and card waste fiber) showed different tendency when compared with clean waste type (sliver and fabric waste fiber). Yarns have a high amount of short fibers waste types showed greater the hairiness values. Depending upon the yarn hairiness, it was showed that increasing the waste fibers caused air permeability negatively [6]. Another study related to the effect of different process parameters at comber stage on yarn and fabric properties for the same noil percentage was studied by Subramanian and Gobi [7]. There are some other studies about noil percentage effects at different raw materials, blend ratio, linear density, spinning system [8-10].

In the light of these researches, there is no systematic paper available about the properties of compact spun yarns produced with different cotton noil percentage at different twist coefficients and yarn linear density. In that respect, compact yarns with different linear density were produced at three different twist coefficient and combed noil percentage. Yarn properties such as tenacity, elongation, unevenness, imperfection index and hairiness values were determined. Also, analysis of variance (ANOVA) and regression analysis were carried out in order to evaluate the significance effect of

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combing noil percentage, twist coefficient and yarn linear density on yarn quality parameters at 95% confidence interval.

2. Materials and methods

Combed cotton yarn samples were manufactured by using compact yarn spinning system. The properties of cotton fiber used as raw material are illustrated in Table 1. Machines used in the production line are shown in Figure 1. In addition, compact spun yarn production process parameters are given in Table 2. In the production of the yarn samples, all parameters were kept constant in order to eliminate process parameters. Totally, 18 yarn samples were produced.

Before the tests, all yarn samples were conditioned under standard laboratory conditions (20±2ºC and 65±4%) in accordance with BS EN ISO 139 standard. Tenacity and elongation tests were carried out according to BS EN ISO 2062 standard at 500 mm gauge length and 5000 mm/min by using Uster Tensorapid 4 device. Unevenness, imperfections and hairiness values were determined by using Uster Tester 6 at 400 m/min test speed all through 2.5 minutes according to ISO 16549 standard. Test results were interpreted statistically using factorial analysis to determine analysis of variance by means of Minitab package program at 95% confidence interval and regression analysis was carried out. Table 3 displays design of experiment for factorial analysis.

Table 1. Properties of cotton fiber.

Fiber Fineness, (Mikronaire)	4.88
Length, (mm)	30.82
Tenacity, (g/tex)	34.22
Elongation, (%)	7.1
Uniformity Index, (%)	84.40
Short Fiber Index (SFI), (%)	6.8
Brightness (Rd), (%)	75
Yellowness, (+b)	8.98

Table 2. Compact yarn production parameters.

Carding Machine	Sliver Linear Density, tex 5906		Speed, (kg/h) 45	
Drawframe	Passage 1	Sliver Linear Density, tex 4922	Doubling 6	Draft 7.2
Lap Machine	Doubling 24		Lap Linear Density, (ktex) 80	
Comber	Doubling 8	Sliver Linear Density, (tex) 4922	Detaching Distance 14%: 8 16%: 9 18%: 10	Feeding Arrangement Forward Feed
Drawframe	Passage 2	Sliver Linear Density, (tex) 4922	Doubling 6	Draft 6
Roving Frame	Roving Linear Density, (tex) 656	Twist, (T/m) 42	Draft 7.5	
Ring Spinning	Yarn Linear Density, (tex) 19.7 14.8	Twist Coeffiecient, (α_e) 3 3.5 4	Break-Draft 1.18 1.18	Total Draft 39.3 52.4

Table 3. Design of experiment.

Independent Parameters	Yarn Linear Density, (tex) 19.7 and 14.8	Combed Noil Percentage, (%) 14, 16 and 18	Twist Coefficient, (αe) 3, 3.5 and 5
Response Variables	Tenacity, (RKM) Elongation, (%) Unevenness, (Cvm%) Imperfection Index, (IPI) Hairiness, (Uster H)		

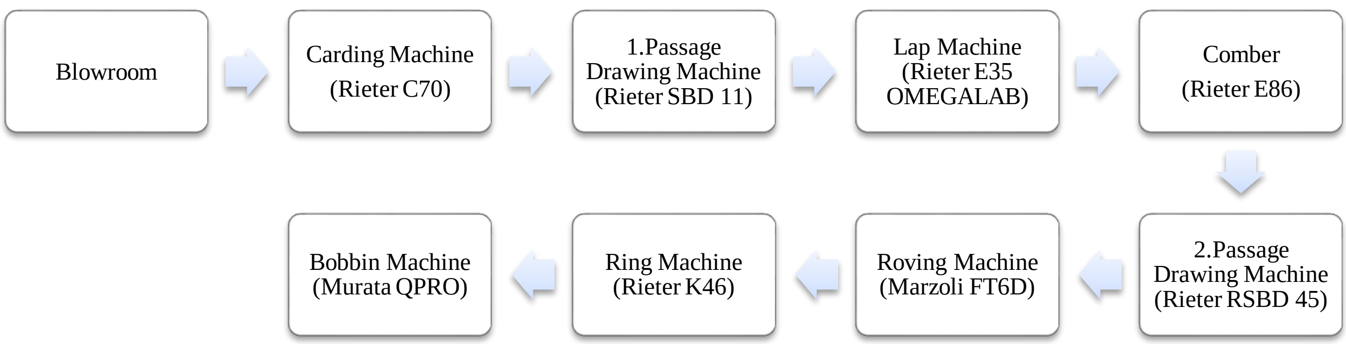

Figure 1. Production line of compact yarn production

3. Results and discussion

In this study, an attempt has been made to improve yarn quality by adjusting the percentage of comber noil. With this respect, yarn linear density, comber noil percentage and twist factor parameters were chosen in order to produce compact yarn samples and to determine the effects of all these parameters on yarn properties.

3.1. Tensile properties

Figure 2 illustrates tenacity results as interaction plots with respect to yarn linear density, twist factor and noil percentage. As seen in Figure 2, tenacity is found to be decrease from coarser to finer yarn. This situation is probably caused from the lower number of the fibers within the cross-section of the yarn structure that enables fibers separate easily. It is well known that removing short fiber in combing process enhances yarn properties and also provides better tenacity. Furthermore, increasing twist factor affects tenacity of the yarn samples for each yarn linear density, positively. It is usually known that twist contributes the tenacity as well. It also appears that the average value of tenacity at the same linear density slightly decreases as the comber noil percentage increases. It is due to the fact that as the comber noil percentage increases, the short fibers are better removed from fiber bundle which leads to easily separate from each other.

When yarn linear density increase is taken into consideration, elongation at break of yarn samples also increase (Figure 3). For finer yarn, lower number of the fibers lead to separation of fibers readily. On the other hand, it is also observed that the average elongation at break decreases as the comber noil percentage increases. While comber noil percentage alters from lower to higher values in the combing machine, more short fibers are removed and finally fibers will be more parallel in the yarn structure that enables the fibers separate from each other easily. As twist factor increases, the elongation at break trends of the yarn samples are seen as increasing.

3.2. Unevenness

In Figure 4, it is seen that there is an improvement in yarn unevenness with the decrease in the short fiber ratio in the yarn (increasing noil percentage). This situation was also seen in both yarn linear densities. It was observed that there was an increase in the unevenness values for thinner yarn. In addition, it was observed that the unevenness values of compact yarn with linear density of 14.8 tex was the highest in yarn with twist factor 4 and lowest in yarn with twist factor 3. It was determined that the compact yarn with 19.7 tex linear density, 3.5 twist factor and 14% noil percentage has the highest unevenness value.

3.3. Imperfection index

The imperfection index (IPI) values of the yarn samples were determined by summing the thin place (-40%/km), thick place (+50%/km) and neps (+200%/km) values. As shown in Figure 5, it was determined that the IPI values increased with the increase in yarn linear density, that is, when the yarn got thinner. With the change of twist factor values from 3 to 4, it was seen that the IPI values of 14.8 tex linear density yarns are in the decreasing trend. However, this situation is not seen in the IPI values of the yarns with a linear density of 19.7 tex. As an interesting result, it was determined that the lowest IPI value was in the yarn with a twist factor of 3.5. However, a decreasing in IPI values is expected when the noil percentage changes from 14 to 18 because of the higher elimination of short fiber. However, it is not seen in the IPI values of the yarns with 16% noil percentage.

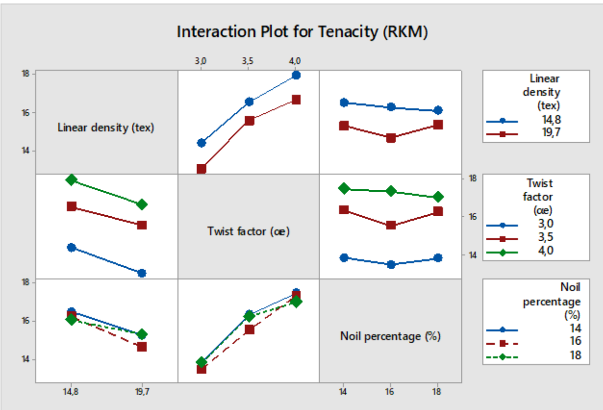

Figure 2. Tenacity values of yarn samples

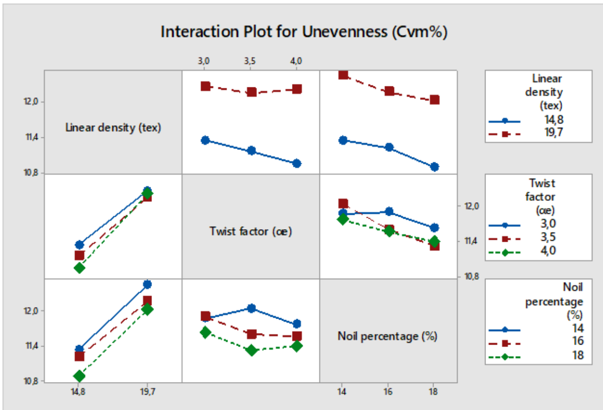

Figure 4. Unevenness values of yarn samples

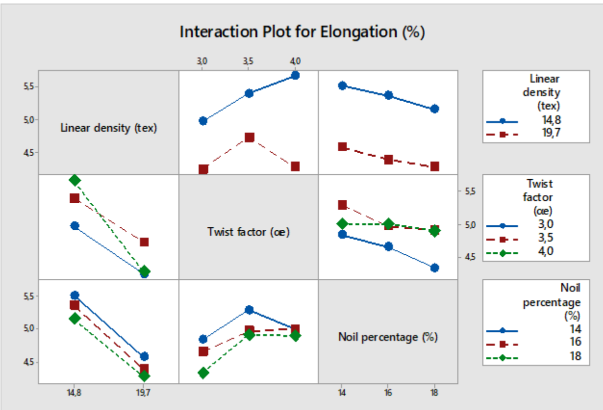

Figure 3. Elongation values of yarn samples

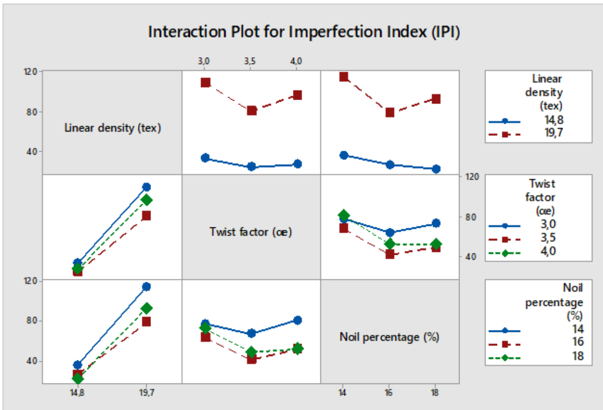

Figure 5. Imperfection index values of yarn samples

3.4. Hairiness

One of the most important parameters affecting yarn hairiness is the percentage of short fibers. An improvement in yarn hairiness is an expected result with the elimination of short fibers. However, it was determined that the yarn hairiness values were lower in fine yarn samples (19.7 tex). It was determined that the hairiness value decreased as a result of the increase in the twist value of the yarn with the increase of the twist factor. It was clearly seen that there was a decrease in hairiness values of all yarn samples with the change of noil percentage values from 14% to 18%.

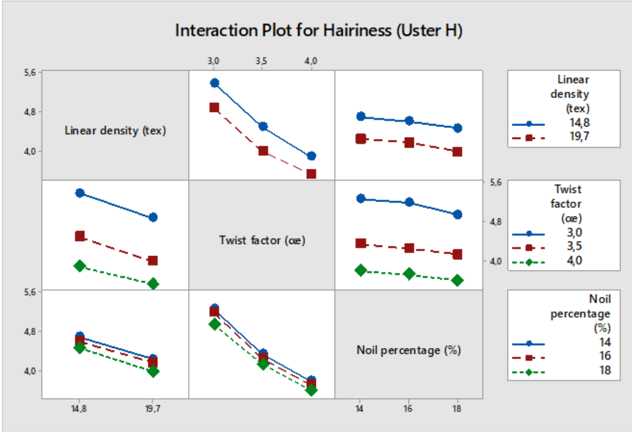

Figure 6. Hairiness values of yarn samples

3.5. Statistical analysis

ANOVA analysis and regression analysis results of yarn samples are illustrated in Table 4 and Table 5, respectively. ANOVA test results of all response variables is taken into consideration, yarn linear density (A), twist factor (B) and noil percentage (C) parameters have statistically significant effect at %5 level (p=0.000). It was observed that interaction of A*B was no statistically significant effect on the tenacity (p=0.138). On the other hand, interaction of A*C and B*C parameters were found to have a significant effect on yarn tenacity. When the ANOVA of the elongation was examined, it was concluded that the interaction of A*B and B*C had a statistically significant effect, but the effect of the interaction of A*C was not statistically significant. When the ANOVA results of other response variables were examined, it was observed that the interactions of A*C and A*B had statistically significant effects on IPI and hairiness, respectively.

We can say that the regression model shown in Table 5 is statistically significant for all response variables (p<0.0001). In other words, we can express yarn linear density, twist factor and noil percentage parameters as meaningful predictors of response variables. Regression equation for tenacity is shown as (Eq.1) and it was found that analysis explains about 91% as Adjusted R^2 value for the model. This situation indicates that a true goodness of fit. Adjusted R^2 was found as 82 % for elongation statistical analysis. Unevenness and IPI regression equations are given as (Eq.3) and (Eq.4), respectively. We can say that the best regression prediction was determined for the hairiness value with an Adjusted R^2 value of 95.15%. In other words, these independent parameters are the best predictors of hairiness.

Table 4. ANOVA analysis results.

Independet parameters/ Response variables	Yarn linear density (A)	Twist factor (B)	Noil percentage (C)	A*B	A*C	B*C
Tenacity (RKM)	0.000*	0.000*	0.000*	0.138	0.000*	0.000*
Elongation (%)	0.000*	0.000*	0.000*	0.000*	0.496	0.003*
Unevenness (Cvm%)	0.000*	0.027*	0.000*	0.084	0.515	0.105
I.P.I.	0.000*	0.003*	0.000*	0.170	0.038*	0.472
Hairiness (Uster H)	0.000*	0.000*	0.000*	0.048*	0.681	0.354

*Statistically significant at 0.05 level

Table 5. Multiple regression analysis results.

Regression Equation A:Yarn Linear Density; B:Twist Factor; C:Noil Percentage	Adjusted R^2	Adjusted Sum of Square	F-value	p-value
Tenacity (RKM)= 136.9 - 8.07 A - 31.28 B- 8.04C + 2.123 A*B+ 0.486 A*C+ 2.163 B*C- 0.1319 A*B*C (Eq.1)	0.9094	222.039	125.70	<0.0001
Elongation (%)=19.2 - 0.519 A - 2.50 B- 1.289 C + 0.077 A*B+ 0.0508 A*C+ 0.327 B*C-0.0135 A*B*C (Eq.2)	0.8243	24.1585	59.32	<0.0001
Unevenness (Cvm%)= 44.7 - 1.87A- 9.90 B - 1.98 C+ 0.590 A*B+ 0.1147 A*C+ 0.528 B*C- 0.0324 A*B*C (Eq.3)	0.7733	29.3780	43.39	<0.0001
Imperfection Index (IPI)= 1447 - 92.2 A- 481 B - 103.5 C+ 32.5 A*B+ 6.86 A*C+ 30.7 B*C- 2.10 A*B*C (Eq.4)	0.7142	109645	32.06	<0.0001
Hairiness (Uster H)= 19.67 – 0.441 A – 3.77 B- 0.446 C+ 0.107 A*B + 0.0159 A*C + 0.118 B*C- 0.00500 A*B*C (Eq.5)	0.9515	35.5512	244.89	<0.0001

4. Conclusion

Within the scope of this study, the effect of the waste percentage in the comber on the yarn quality properties was investigated. In this context, twist factor and yarn linear density parameters are also included in the study, as well as noil percentage. Tenacity, elongation, unevenness, IPI and hairiness properties were determined. Results are summarized as follows;

- Yarn linear density, twist factor and noil percentage parameters were found to have statistically significant effects on the analyzed yarn properties.
- It was determined that the yarn Cvm%, hairiness and elongation values decreased with the increase of the noil percentage ratio. In other words, it can be said that there is an improvement in yarn unevenness and hairiness. However,

when IPI and tenacity values are examined, it is seen that the lowest values are obtained in 16% noil percentage yarn.

- With the thickening of the yarn, it was determined that the yarn IPI, unevenness, tenacity and elongation properties improved. However, it was also determined that the hairiness values of the yarns with a linear density of 14.8 tex were higher.
- It was determined that the yarn strength values increased with the increase of the twist factor.

Author contributions

Halil İbrahim Çelik: Investigation, methodology, data curation, conceptualization, supervision writing, review & editing

Özhan Çoban: Funding acquisition, methodology, conceptualization, data curation, organization and production of the samples, testing

Esin Sarıoğlu: Visualization, writing-original draft, statistical analysis, writing, review &editing

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