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The effect of cotton fibre characteristic on yarn properties

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Abstract: In this study, the effects of cotton fibre properties on the tenacity, elongation, unevenness and hairiness of the compact yarns were investigated in detail. For this purpose, compacted yarns having four different yarn counts as Ne 30/1, 40/1, 50/1 and 60/1 with similar twist coefficient between α_e 4.2-4.4 were produced systematically. The fibre, sliver, roving and yarn, that in cops and package form, properties were measured step by step from the beginning to the end of yarn production. According to the findings, unevenness, imperfections, hairiness, breaking strength and elongation results of the compact yarns were evaluated taking into account unevenness results of sliver and roving, and fibre properties tested by High Volume Instruments (HVI).
Keywords: Cotton, compact yarn, HVI, unevenness, hairiness, tenacity.

1. Introduction

In order to produce high quality yarn, choosing the appropriate cotton for the field of use, quality of fibre properties and efficient use of fibre blends are priority requirements. Fibre cost constitutes more than 50% of the producing cost of cotton yarn, and quality properties of yarn change depending on the fibre quality. Considering this fact, many researchers have studied the effect of raw materials and spinning condition on yarn properties [1-8]. In this study, the quality properties of the materials were measured at each stage of production and very thin cotton compact yarns at different yarn count were investigated differently from the literature.

2. Materials and methods

In this study, four different types of cotton compact yarn at different linear densities were produced on the Saurer Zinser 35 2Impact FX compact spinning machine. The cotton bales that used in the study were mixed at the same blow room. Trützschler TC11 type carding machine was used. Two passages drawing process was used with Trützschler TD7 and Trützschler TD8. Rieter E 80 combing machine was used for combing processes and Saurer Zinser 670 machine was used to produce roving. The cotton compact yarns that produced in the study are presented in Table 1.

Table 1. The yarns produced in the study

Sample Code	Yarn Count (Ne)	Twist Coefficient (α_e)
1	30.15	4.20
2	39.92	4.21
3	49.88	4.31
4	59.74	4.39

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The fibres, slivers and yarns were preconditioned in a conditioning room at standard atmospheric conditions (20 ± 2°C, 65 ± 2% RH) for 24 hours The fibre properties were measured on High Volume Instruments (HVI) in accordance with ASTM D4605. By using Uster Tester 4 and Uster Tensorapid-3, the measurements of breaking strength, elongation, hairiness and unevenness properties were performed in accordance with Uster and ASTM D2256 standards. The obtained results were evaluated in 95% confidence interval (α=0.05) using SPSS 23.0 statistical software and by applying variance and Pearson's correlation and regression analyses.

3. Results and discussion

The fibre properties, carding, draw and roving sliver properties, unevenness, imperfections, hairiness, breaking strength and elongation properties of the yarns were measured in the study.

Uster HVI Testing System was used to determine all the physical and quality properties of the Aegean and South East Anatolian regions of Turkey's cotton fibres used in the study. The cotton samples were collected from cotton bales of the blends, which were prepared for each of the yarn count. The mean properties of the cotton fibre blends formed for each yarn count are presented in Table 2.

Table 2. The quality properties of the cotton fibres used in the study

Property	Blend for Ne 30	Blend for Ne 40	Blend for Ne 50	Blend for Ne 60
Neps	222.38	250.67	99.91	82.72
Spinning Consistency Index (SCI)	135.17	119.00	148.66	164.95
Micronaire	4.50	4.56	4.74	4.66
Maturity Index	0.86	0.87	0.88	0.91
Length (mm)	29.18	29.19	29.86	30.19
Uniformity	81.87	81.37	83.77	83.94
Short Fibre Index	8.89	8.33	6.58	6.32
Strength (g/tex)	31.16	30.30	33.62	38.23
Elongation (%)	10.96	10.93	11.10	10.89
Moisture Content (%)	6.08	6.57	7.49	6.96
Reflectance (Rd)	77.08	65.90	69.53	70.55
Yellowness (+b)	8.09	8.20	7.94	7.97
Trash Area (%)	0.59	0.34	1.07	1.07
Trash Grade	4.00	2.67	5.78	5.95

As seen in the HVI results, the fibre properties improve in finer yarn counts, in general. This state is also confirmed by SCI, which is a calculation from micronaire, uniformity strength and reflection and uses for predicting the overall quality and spinnability of the cotton fibre. Besides, the higher SCI value shows that the better quality yarn can be produced.

The unevenness (CV%) measured by Uster Tester of the carding, draw and roving slivers are shown in Table 3. As expected, the unevenness of the slivers is decreased from first to second passage drawing. The highest unevenness value is seen for Ne 40 slivers in roving form.

Table 3. The unevenness properties of the slivers

Property	Sliver for Ne 30	Sliver for Ne 40	Sliver for Ne 50	Sliver for Ne 60
CV% of the Carding	2.55	2.66	2.51	2.45
CV% of the I. Drawing	3.23	2.57	2.98	2.47
CV% of the II. Drawing	2.46	1.84	2.23	2.01
CV% of the Roving	3.44	5.34	3.02	3.21

The results of the tenacity (RKM) and elongation at break of the yarns are given in Figure 1 and Figure 2, respectively. As understood from the tensile strength results, Tenacity values of the yarns decrease with the increase of the yarn count. Similarly, elongation ability of the yarns decreases when yarns become thinner. Although fibres used for Ne 60 have the highest strength values, the tenacity of these yarns is lower. The reduction of the number of fibres in the cross-section of the yarn when yarn becomes thinner may be reason for this result.

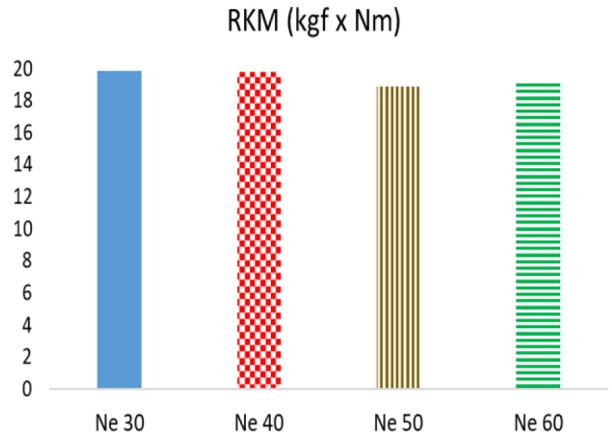

Figure 1. Tenacity values of the yarns produced in the study.

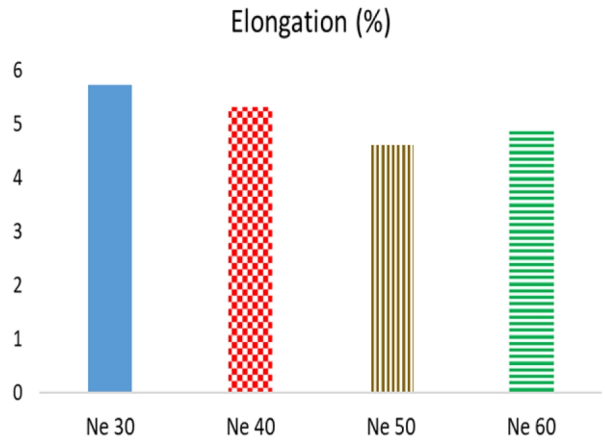

Figure 2. Elongation values of the yarns produced in the study.

The results of the imperfections as thin places (-50%/km), thick places (+50%/km) and neps (+200%/km) of the yarns are given in Table 4. As seen from the results, the imperfections of the yarns increase with the increase of the yarn count. In spite of cotton fibres blended for making thinner yarns have low neps content, they have higher neps values in yarn form.

Table 4. The imperfection values of the yarns

Yarn Count	Thin (-50%/km)	Thick (+50%/km)	Neps (+200%/km)
Ne 30	0.43	16.21	16.43
Ne 40	0.52	19.46	47.59
Ne 50	5.16	33.80	50.12
Ne 60	13.03	38.38	80.15

The results of the unevenness (CV%) of the yarns are illustrated in Figure 3. It is observed that the unevenness of the yarns increases with the increase of yarn count. In terms of tensile strength results, there was an opposite condition to the results of unevenness. Besides CV% values of the yarns change between 12.19-13.74, which are good values in terms of yarn regularity.

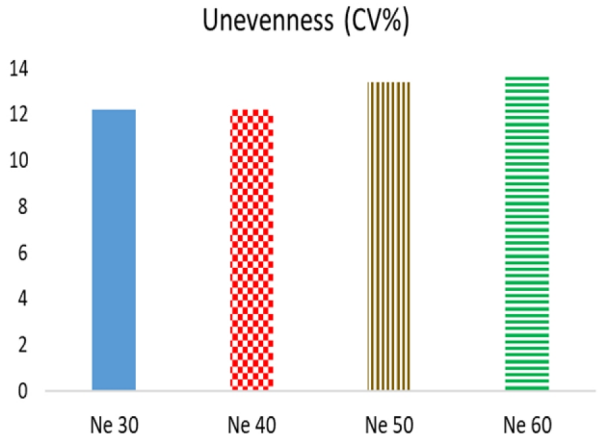

Figure 3. Unevenness values of the yarns produced in the study.

The hairiness values of the yarns produced in the study are shown in Figure 4. An evaluation of the effect of yarn count on hairiness shows that the hairiness values of the Ne 60 yarns are the lowest whereas Ne 30 yarns are the lowest. When yarn becomes thinner, fibres join the structure better and less prone to go out from the yarn axis. Actually, another most important fibre parameters that affects hairiness after yarn count is the amount of trash. However, trash content of the fibres has less effect on the yarn hairiness according to the results of the study.

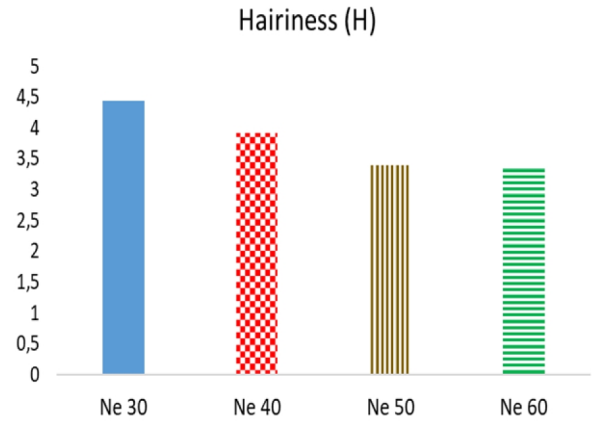

Figure 4. Hairiness values of the yarns produced in the study.

In order to investigate the relationship between fibre properties and yarn properties, Pearson correlation coefficients were calculated and the results are given in Table 5. According to the correlation analyses results, generally the correlation coefficients between fibre and yarn parameters are statistically significant at significance level of α=0.05. This finding shows that, fibre properties measured in this study may be used for estimating yarn properties. As expected, yarn tenacity has

statistically significant correlations with fibre length, uniformity and strength in positive direction, whereas it has statistically significant correlations with neps, short fibre index and trash content in negative direction. Elongation ability of the yarns has positive correlation with fibre fineness and moisture content, and has negative correlation with short fibre index. As understood from the correlation analysis, when neps, short fibre index and trash content in the blend increase, unevenness of the yarn increases. Besides, the increase of fibre fineness, maturity, length and uniformity causes the reduction of unevenness of the yarn. According to the yarn hairiness correlation analysis it is found that, neps, short fibre index and trash in the fibre blend make high hairiness on the yarn surface.

Table 5. Correlations between fibre and yarn properties

		Yarn Properties			
		Tenacity	**Elongation**	**Unevenness**	**Hairiness**
Fibre Properties	**Neps**	-0.952*	0.832	0.983*	0.941*
	Micronaire	0.972*	0.983*	-0.861	-0.932*
	Maturity	0.511	0.728	-0.954*	-0.861
	Length	0.940*	0.815	-0.995*	-0.948*
	Uniformity	0.954*	0.831	-0.977*	-0.830
	Short Fibre Index	-0.965*	-0.934*	0.983*	0.967*
	Strength	0.943*	0.604	-0.819	-0.743
	Elongation	0.412	0.842	0.106	-0.161
	Moisture Content	0.436	0.933*	0.803	-0.216
	Reflectance	0.254	0.515	-0.183	0.571
	Yellowness	0.903	0.740	-0.787	0.680
	Trash Area	-0.937*	-0.757	0.936*	0.941*
	Trash Grade	-0.894	-0.776	0.932*	0.904

* Correlation coefficients are significant at 95% confidence level

In other respects, linear regression models were established to estimate the yarn tenacity, elongation unevenness and hairiness from fibre parameters. The calculated linear regression models for the yarn properties are presented below:

Tenacity= -10.121 + 0.811 Strength + 0.257 Length – 0.411 Short Fibre Index (R=0.861)

Elongation= 23.562 – 7.943 Micronaire + 1.815 Elongation – 0.22 Short Fibre Index (R=0.907)

Unevenness= -15.829 + 10.789 Neps + 0.253 Short Fibre Index – 0.215 Uniformity (R=0.836)

Hairiness= 4.354 + 0.731 Trash Area + 0.496 Short Fibre Index – 1.056 Micronaire (R=0.886)

The linear models were selected from different equations with take an attention adjusted R square values. This shows that the linear regression models which contain the parameters calculated by the method used in this study provide a valuable estimation of yarn properties.

4. Conclusion

This study focuses at examining and evaluating the relation among fibre properties, process controlling and yarn properties. The test results have revealed the relation between cotton fibre properties, slivers and yarn properties, and the performance of thin cotton compact yarns.

The results show that the unevenness of the yarns increases with the increase of yarn count, while there was an opposite condition in tensile strength values according to the results of unevenness. As understood from the findings, yarn tenacity increases with the increase of fibre length, uniformity and strength, whereas it decreases with neps, short fibre index and trash content. Extensibility of the yarns increase with increase of the fibre fineness and moisture content, and it decreases with short fibre index in the fibre blend. On the other hand, unevenness and hairiness of the yarns increase with increase of neps, short fibre index and trash content in the blend. Besides, the increase of fibre fineness, maturity, length and uniformity causes the reduction of unevenness and hairiness of the yarn. Moreover, linear regression models were established to estimate yarn properties from other fibre parameters and valuable estimation models were obtained.

The findings of this study may be helpful for predicting yarn properties from fibre characteristic studies and cotton yarn manufacturers.

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