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Research Article

The Effect of Licker-In Speed of the Carding Machine on Yarn Quality

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Abstract

The aim of this study is to investigate the effect of four different licker-in speeds (850, 1200, 1550, and 1900 rpm) on yarn quality parameters such as unevenness, imperfection index (IPI) values and hairiness (H) according to two different yarn count categories (Ne24/1 and Ne30/1). Carded ring yarn samples were produced in the carded yarn production line using the machines of Rieter company. The results show that while there is not a statistically significant difference in U (%) (unevenness), CVm (%) and IPI values according to licker-in speed, there is a significant difference in yarn hairiness values. Furthermore, the results showed similarity across all quality parameters concerning both yarn count categories. An optimum licker-in speed has been achieved and suggested in the hairiness parameter in terms of licker-in speed. The results of this study are expected to shed more light into yarn quality research. Also, the results will help both researchers of the same interest and the manufacturers who want to reach an optimum production level in terms of both quality and cost.

Keywords: Carding machine, Licker-in speed, Unevenness, Ipi, airiness.

Tarak Makinası Brizör Hızının İplik Kalitesi Üzerindeki Etkisi

Öz

Bu çalışmanın amacı, dört farklı brizör hızının (850, 1200, 1550 ve 1900 d\d) iki farklı iplik numarası kategorisine (Ne24/1) ve (Ne30/1) göre düzgünsüzlük, hata indeksi (IPI) değerleri ve tüylülük (H) gibi iplik kalite parametreleri üzerindeki etkisini araştırmaktır. Karde ring iplik numuneleri, karde iplik üretim hattında Rieter firmasının makinaları kullanılarak üretilmiştir. Analiz sonuçları, brizör hızına göre U(%) (düzgünsüzlük), CVm(%) ve IPI değerlerinde istatistiksel olarak anlamlı bir fark yokken, iplik tüylülük değerlerinde anlamlı bir farklılık olduğunu göstermektedir. Ayrıca sonuçlar, her iki iplik numarası kategorisine ilişkin tüm kalite parametrelerinde benzerlik göstermiştir. Tüylülük parametresinde brizör hızı açısından optimum bir brizör hızı elde edilmiş ve önerilmiştir. Bu çalışmanın sonuçlarının iplik kalitesi araştırmalarına daha fazla ışık tutması beklenmektedir. Ayrıca, bu araştırmanın sonuçlarının gerek aynı alandaki araştırmacılara gerekse hem kalite hem de maliyet açısından optimum üretim seviyesine ulaşmak isteyen üreticilere yardımcı olması beklenmektedir.

Anahtar Kelimeler: Tarak makinası, Brizör hızı, Düzensizlik, Ipi, Tüylülük.

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1. Giriş

Carding is an important operation in yarn spinning as the quality of the end product of the spinning process enormously depends on carding [1,10,13]. Productivity and quality of the yarn are immensely correlated with this process [2,3,11]. The main aim of the carding machine is to individualize fibers during the carding process which leads an improvement in yarn properties. In order to reduce the cost of yarn production, the phases in the carding process should be taken into consideration. One of these process phases is the licker-in speed. Various yarn properties are affected by the action in licker-in. The main objective of this phase is to open up the fiber tufts. By adjusting the licker-in speed, the insufficiencies resulted by wire pitch or fiber breakages due to high speed can be eliminated in the yarn production [4,12].

High production rates can be achieved through maximum licker-in speed. However, this may negatively affect the yarn quality. Optimum speed is necessary to obtain better quality in yarn. Otherwise, fibers can be damaged because of high licker-in speed. According to the research results, fiber rupture, hairiness and imperfection can increase and yarn strength can decrease as a result of increased licker-in speed. That is, short-fiber content is increased because of the increases in fiber rupture and this leads to high yarn imperfection and low strength [5]. Research suggests that the peripheral speed variation between the cylinder and the licker-in speed causes fiber damage or breakage and increased unevenness (U%) as the speed of the licker-in increases [6]. The aim of speeding up the licker-in is to ensure improved cleaning of waste, material and short fibers which will result in improved neps removal [7]. However, study results reveal that the high rupture of fiber and appearance of short fibers in the yarn are caused by the increased speed of the licker-in and this leads to increased hairiness [8]. Furthermore, the higher the licker-in speed gets, the more increased variation in the yarn is observed due to fiber breakage and damage [9]. Yarn strength is improved and IPI values and hairiness decrease with a lower speed of licker-in [7]. Another study results demonstrate that, the increased harsh beating in higher licker-in speeds leads to better cleaning, but this efficacy of neps removal happens up to a certain limit and then this efficacy starts to decrease after a certain limit of licker-in speed [10].

As suggested in the literature, an optimum speed should be achieved in the licker-in process to obtain better yarn quality in low costs. The studies conducted so far on licker-in speed have mostly focused licker-in speed by combining the effects of other phases in the carding process. The quality parameters, i.e. U (%), CVm (%), IPI values, hairiness and strength, are known to be affected by other factors such as yarn count (Ne) in the yarn production process. Thus, investigating the effect of licker-in speed on yarn quality according to different yarn counts can have an indication in finding the optimum speed in licker-in process. Considering these facts, this study aims to find out the effect of licker-in speed on yarn qualities based on two different yarn counts (Ne).

2. Materials and Method

2.1. Materials

Cotton samples taken from various parts of the cotton blend used within the scope of the study were measured three times with the help of the Uster HVI 1000 (High Volume Instrument) test device and the averages of the values found as a result of these measurements are shown in Table 1.

Table 1. Cotton Fiber Uster HVI 1000 Measurement Values

	x̄	SD
Spinning Consistency Index	134	5.0
Micronaire (µg/inch)	4.94	0.06
UHML (mm)	30.01	0.20
Maturity Index	0.87	0.01
Uniformity Index (%)	83.2	0.8
Short Fiber Index (%)	7.6	0.7
Strength (g/tex)	30.8	1.5
Elongation (%)	7.3	0.1
Reflectance (Rd)	76.1	0.6
Yellowness (+b)	8.6	0.3

The carded yarn production line using the machines of Rieter company is presented in Figure 1.

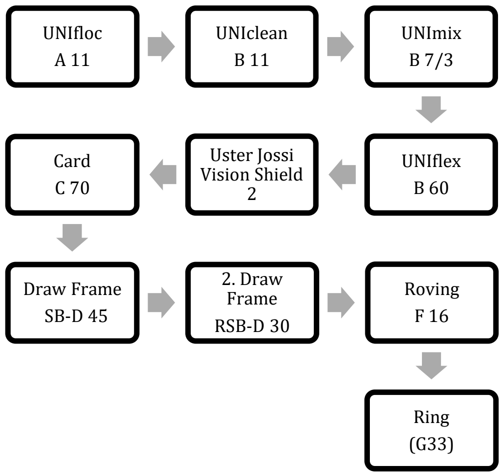

Figure 1. Yarn production line

As shown in Figure 1, Ne 24/1 and Ne 30/1 carded ring yarn production was carried out separately for each licker-in speed value in the carded yarn production line. The yarn production parameters in the sample yarn production stages are shown in Table 2.

Table 2. Parameters in yarn production

Parameters	**24/1**	**30/1**
Card, Draw Frames Sliver **(Ne)**	0.120	0.120
Card Flat Speed **(m/min)**	0.32	0.32
Card Cylinder Speed **(m/min)**	756	756
Card Sliver Output Speed**(m/min)**	200	200
Roving Hank **(Ne)**	0.90	0.90
Roving Twist **(T/inch)**	1.18	1.18
Yarn Twist **(T/m)**	716	833
Ring Speed **(rpm)**	13500	14500
Break draft **(G33)**	1.19	1.19
Ring traveller **(ISO)**	50.0	40.0
Pin spacer size **(mm)**	3.75	3.50
Cots diameter **(mm)**	30.0	30.0
Cots hardness **(shore)**	63	63

2.2. Method

The data were analyzed by using a statistical analysis program. In order to understand the effect of licker-in speed on yarn quality parameters according to yarn count one-way ANOVA analysis was conducted. For the statistically significant relationships in the ANOVA results, Scheffe Post-hoc analysis was done to understand between which groups that significant relationship was.

3. Results and Discussion

In this section the results are grouped and presented in the order of quality parameters as: yarn irregularity (U% and CVm %), IPI values, and hairiness (H). The descriptive statistics and one-way ANOVA analysis results for yarn unevenness are given in Table 3.

Table 3. Descriptive Statistics and One-way ANOVA Analysis Results for Yarn Unevenness Values

			N	Mean	SD		Sum of Squares	df	Mean Square	F	p
Ne 24/1	U(%)	**850**	10	10.5290	0.12758	Between Groups	0.153	3	0.051	2.235	.0101
		1200	10	10.3640	0.12349						
		1550	10	10.4140	0.21381	Within Groups	0.823	36	0.023		
		1900	10	10.3990	0.11902						
		Total	40	10.4265	0.15819	Total	0.976	39			
	CVm(%)	**850**	10	13.4220	0.15831	Between Groups	0.217	3	0.072	1.845	0.157
		1200	10	13.2230	0.16700						
		1550	10	13.2910	0.27610	Within Groups	1.413	36	0.039		
		1900	10	13.2710	0.16683						
		Total	40	13.3018	0.20446	Total	1.630	39			
Ne 30/1	U(%)	**850**	10	11.0170	0.25799	Between Groups	0.108	3	0.036	0.559	0.645
		1200	10	10.9360	0.24019						
		1550	10	10.9640	0.18857	Within Groups	2.325	36	0.065		
		1900	10	11.0720	0.31382						
		Total	40	10.9973	0.24977	Total	2.433	39			
	CVm(%)	**850**	10	14.0560	0.33939	Between Groups	0.092	3	0.031	0.240	0.868
		1200	10	13.9930	0.41139						
		1550	10	14.0040	0.40505	Within Groups	4.610	36	0.128		
		1900	10	14.1140	0.40953						
		Total	40	14.0417	0.34722	Total	4.702	39			

As seen in Table 3, the analysis results reveal that there is no statistically significant relationship between licker-in speed and U (%) and CVm (%), for Ne24/1 – U(%) F(3.36)=2.235; for Ne24/1-CVm(%) F(3.36)=1.845, for Ne30/1- U(%) F(3.36)=0.599 and for Ne30/1 – CVm(%) F(3.36)=0.240, p>.05. The results are the same for both yarn counts defined for this study. However, it has been found that although the highest mean value ($\bar{x}$=10.52 and $\bar{x}$=13.42) for unevenness have generally been obtained in the lowest licker-in speed (850 rpm) in Ne24/1 yarn count, the situation for Ne30/1 yarns have been just the opposite. For this yarn count the highest mean value ($\bar{x}$=10.99 and $\bar{x}$=14.11) have been obtained in the highest licker-in speed. The graphic for the mean values of U (%) and CVm (%) parameters are presented in the Figures 2 and 3.

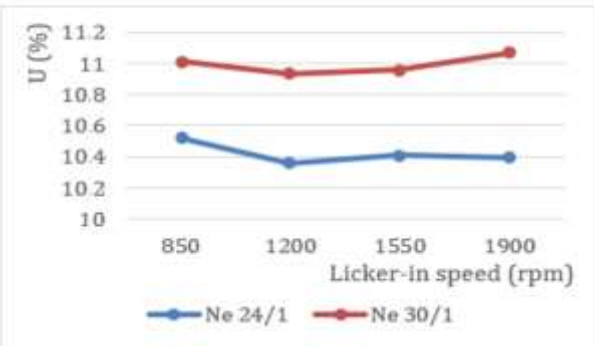

Figure 2. U (%) values

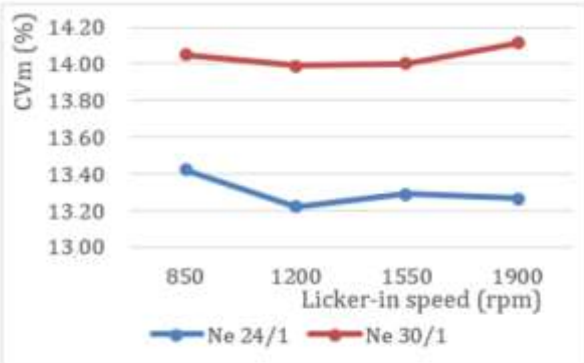

Figure 3. CVm (%) values

The figures demonstrate that there is a linear distribution for unevenness in the yarn and this is same for both yarn counts. However, the small variations in the mean values indicate a slight difference in the mean values according to the licker-in speed. As suggested in the literature, it is expected to observe higher unevenness in the yarn produced though higher licker-in speeds [6], as found in this study for Ne30/1 yarns. What is unexpected is that with Ne24/1 yarns, it is the lowest licker-in speed that led to increased unevenness. This is a small, but notable finding which can be further investigated with wide range yarn count numbers.

The descriptive statistics and one-way ANOVA analysis results for IPI values are given in table 4 below.

Table 4. Descriptive Statistics and One-way ANOVA Analysis Results for Yarn IPI Values

		N	Mean	SD		Sum of Squares	df	Mean Square	F	p
Ne24/1	**850**	10	305.7500	29.83869	Between Groups	5823.125	3	1941.042	1.396	0.260
	1200	10	307.0000	26.47850						
	1550	10	288.5000	52.07100	Within Groups	50038.750	36	1389.965		
	1900	10	278.2500	35.45439						
	Total	40	294.8750	37.84648	Total	55861.875	39			
Ne30/1	**850**	10	447.2500	65.57915	Between Groups	2341.250	3	780.417	0.136	0.938
	1200	10	451.2500	79.90663						
	1550	10	445.5000	67.09032	Within Groups	206521.250	36	5736.701		
	1900	10	431.0000	88.09086						
	Total	40	443.7500	73.18093	Total	208862.500	39			

Similar results have been obtained for IPI values according to the licker-in speeds and yarn counts. There is no statistically significant difference between IPI values of the yarn samples produced in both counts (Ne24/1 and Ne30/1) based on the differences in the speed of the licker in, F(3.36)=1.396 for Ne24/1 and F(3.36)=0.136 for Ne30/1, p>.05. The highest IPI mean values obtained in both yarn counts have been in 1200 rpm licker in speed ($\bar{x}$=307 and $\bar{x}$=451.25), and the lowest IPI mean values ($\bar{x}$=278.25 and $\bar{x}$=431) have been obtained through the highest licker-in speed (1900 rpm). The graphic for the IPI mean values are presented in the Figure 4.

The Figure 4 reflects that the high licker-in speeds, regardless of yarn count, decreases IPI since waste and short fibers are better cleaned in higher speeds [7]. The findings of this study concerning IPI values are in-line with the previous research. Additionally, it has been found out that the yarn count does not make any difference in the IPI values in terms of the effect of licker-in speed.

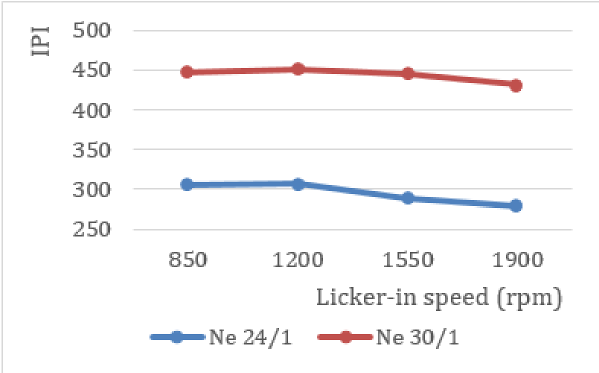

Figure 4. IPI Values

The descriptive statistics and one-way ANOVA analysis results for yarn hairiness are given in table 5 below.

Table 5. Descriptive Statistics and One-way ANOVA Analysis Results for Yarn Hairiness

		N	Mean	SD		Sum of Squares	df	Mean Square	F	p
Ne24/1	**850**	10	6.3890	0.17343	Between Groups	1.281	3	0.427	14.384	0.000
	1200	10	6.3540	0.13134						
	1550	10	6.6760	0.23922	Within Groups	1.069	36	0.030		
	1900	10	6.1770	0.11926						
	Total	40	6.3990	0.24549	Total	2.350	39			
Ne30/1	**850**	10	6.0010	0.32040	Between Groups	1.492	3	0.497	4.644	0.008
	1200	10	6.0600	0.35920						
	1550	10	6.4370	0.33387	Within Groups	3.855	36	0.107		
	1900	10	5.9430	0.29193						
	Total	40	6.1103	0.37028	Total	5.347	39			

The results indicate that there is a statistically significant difference between hairiness values according to licker-in speed in both groups of yarn counts, F(3.36)=14.384 for Ne24/1 and F(3.36)=4.644 for Ne30/1, p<.05. In order to identify where this significant difference occurred Scheffe post hoc analysis was conducted. The results of this analysis is given in Table 6 below.

Table 6. The Scheffe Post-hoc analysis results for yarn hairiness

			Mean Difference	Std. Error	p
Ne24/1	850	1200	0.03500	0.07706	0.976
		1550	-0.28700*	0.07706	0.008*
		1900	0.21200	0.07706	0.073
	1200	850	-0.03500	0.07706	0.976
		1550	-0.32200*	0.07706	0.002*
		1900	0.17700	0.07706	0.173
	1550	850	0.28700*	0.07706	0.008*
		1200	0.32200*	0.07706	0.002*
		1900	0.49900*	0.07706	0.000*
	1900	850	-0.21200	0.07706	0.073
		1200	-0.17700	0.07706	0.173
		1550	-0.49900*	0.07706	0.000*
Ne30/1	850	1200	-0.05900	0.14635	0.983
		1550	-0.43600*	0.14635	0.045*
		1900	0.05800	0.14635	0.984
	1200	850	0.05900	0.14635	0.983
		1550	-0.37700	0.14635	0.104
		1900	0.11700	0.14635	0.887
	1550	850	0.43600*	0.14635	0.045*
		1200	0.37700	0.14635	0.104
		1900	0.49400*	0.14635	0.018*
	1900	850	-0.05800	0.14635	0.984
		1200	-0.11700	0.14635	0.887
		1550	-0.49400*	0.14635	0.018*

*. *The mean difference is significant at the 0.05 level*

The Scheffe analysis results point out significant differences between the hairiness mean values acquired through the licker-in speeds of 850-1550 rpm, 1200-1550 rpm, and 1550-1900 rpm in yarns with Ne24/1 yarn count. Moreover, for the Ne30/1 yarns, the significant results have been obtained between the hairiness mean values through the licker-in speeds of 850-1550 rpm and 1550-1900 rpm. The previous research in the literature notes that the hairiness degrees are heavily dependent on licker-in speed and as the speed increases the hairiness in the yarn increases as well [6,7,8]. The results of this study shows that the minimum hairiness values have been obtained with the licker-in speed of 1900 rpm in both yarn counts (Ne24/1 and Ne30/1). However, the results also signal a linear increase in hairiness values with the licker-in speed up until the speed of 1550 rpm and a harsh decrease in the speed of 1900 rpm. This can be observed in the graphic presented in Figure 5 below.

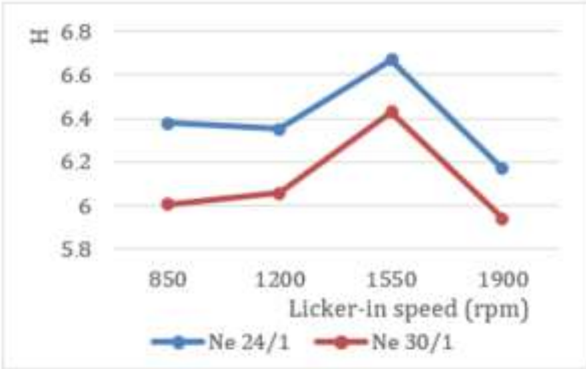

Figure 5. Hairiness Values

As the Figure 5 highlights, there is an increase in the hairiness levels as the licker-in speeds up. On the other hand, there is a sharp decrease in the end where it is normally expected to see the hairiness values at the maximum. It can be inferred from this result that, there is surely an optimum licker-in speed for the hairiness levels in yarn production regardless of the yarn count. It is quite important to find this optimum speed to achieve both better quality yarns in high production rates. It can be said that for the produced material in this study, the optimum licker-in speed is 1900 rpm to get low hairiness levels.

4. Conclusion

This study aimed to explore the effect of various licker-in speeds on yarn quality parameters, i.e. U (%), CVm (%), IPI and hairiness in two different yarn count categories. The statistical analysis displayed complementary results to the literature and pinpointed that the increase in speed also increases unevenness and decreases IPI in yarn, although these findings did not indicate any statistically significant difference between the obtained values according to four different licker-in speeds. On the other hand, the results for hairiness indicated that there is an optimum licker-in speed in which both high quality, i.e. low hairiness, and high productivity can be achieved. These results have only been obtained from the sample yarns specified in this study. Further studies need to be conducted to find out optimum levels for other yarn samples. Furthermore, this study is limited with only four licker-in speeds and two different yarn count categories. Research can be extended by including more licker-in speeds and yarn count categories to find out optimum speeds for better yarn production.

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