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The Impact of Machine and Construction Settings on Sliver and Yarn Quality in Ring Spinning Process[1]

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Abstract

Ring spinning is the most important spinning system with its wide application area, high yarn quality and widespread usage in staple fiber spinning. Each parameter in the long process steps in the ring spinning system significantly influences the yarn quality. Within the scope of this study, the effects of the machine and construction settings on the sliver and yarn properties in each of the blowroom, carding, drawing, combing, roving and spinning processes are examined. In this context, the effect of many parameters such as carding parameters, sleeve type and size, combing type, yarn drawing and twisting settings on the quality characteristics of slivers and yarns have been observed. The effects of setting changes were investigated by examining the whole production process of cotton ring yarns with different yarn count and twisting properties. Breaking strength and elongation at break properties and hairiness, unevenness and imperfections of the materials were analyzed. The actual yarn manufacturing in the ring spinning mill was examined and the relations between production and quality were determined. It is thought that the results obtained will be useful for field studies and scientific researches related to ring yarn spinning.

Keywords: Ring spinning, machine setting, yarn construction, yarn quality, unevenness.

Ring Eğirmeciliğinde Makine ve Konstrüksiyon Ayarlarının Şerit ve İplik Kalitesi Üzerine Etkileri

Özet

Ring iplikçiliği, geniş uygulama alanı, yüksek iplik kalitesi ve elyaf iplikçiliğinde yaygın kullanımı ile en önemli iplik eğirme sistemidir. Ring iplik eğirme sistemindeki uzun proses adımlarındaki her bir parametre iplik kalitesini önemli derecede etkilemektedir. Bu çalışma kapsamında, makine ve konstrüksiyon ayarlarının harman hallaç, tarak, cer, penye, fitil ve eğirme işlemlerinden elde edilen şerit ve ipliklerin özellikleri üzerine etkileri incelenmiştir. Bu bağlamda, tarak makinesi parametreleri, penyeleme işlemi efektifliği, manşon tipi ve ebadı, iplik çekim ve büküm ayarları gibi birçok parametrenin şerit ve ipliklerin kalite özellikleri üzerindeki etkisi gözlenmiştir. Farklı iplik numarası ve büküm özelliklerine sahip pamuklu ring ipliklerinin tüm üretim süreci incelenerek ayar değişimlerinin etkileri incelenmiştir. İplik mukavemeti ve uzama özellikleri, iplik düzgünsüzlüğü ve tüylülüğü analiz edilmiştir. Ring iplik işletmesindeki fiili iplik üretimi incelenmiş ve üretim ile kalite arasındaki ilişkiler belirlenmiştir. Elde edilen sonuçların saha çalışmaları ve ring iplik eğirmesi ile ilgili bilimsel araştırmalar için faydalı olacağı düşünülmektedir.

Anahtar Kelimeler: Ring iplikçiliği, makine ayarları, iplik konstrüksiyonu, iplik kalitesi, düzgünsüzlük.

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1. Introduction

Ring spinning system was found by John Thorp in 1828, and ring frame, ring traveler and other components were added to system in 1830 [1]. In the intervening 170 years, the detail spinning system has been made on the ring spinning machine, but the basic concept has remained the same. Ring spinning meets about 60% of the staple yarn spinning with capacity of 210 million spindles [2]. Many novel yarn spinning techniques have been presented in the trading market, however none of them have not affected to staple fiber spinning like the most versatile ring spinning system. The popularity of ring spinning technique can be depended to high yarn quality, adaptability of all fiber types spinning with very large scale of yarn fineness Ne 6 to Ne 250 as at the present time [3]. The working principle of the system is based on the fact that the fibers which have been parallelized are taken with a drafting system after being brought to the form of band and roving, and converted into a bobbin by twisting with the help of the ring and the traveler [4]. Ring spinning system is composed of very long processes such as blowroom, carding, drawing, combing, roving and spinning. Each parameter in the long process steps in the ring spinning system significantly influences the yarn quality.

Researchers and producers have studied to improve ring spun yarn quality as well as more efficiency to stay a long in a competitive market. Optimizing processes during ring spinning system, engineering design, mechanical variables and constructional settings are very important to increase quality. Many researchers have examined some constructional and raw material parameters on ring spun yarn quality in the literature [5-10].

In this study, workflows, process parameters and quality characteristics were investigated in ring spinning production mill. The effect of carding parameters, combing variables, yarn drawing and twisting settings on the quality properties of the slivers and yarns have been observed. The actual data in the ongoing ring spinning production at the factory were examined and the relations between production and quality were determined.

2. Material and Method

In this study, the 100% cotton ring yarn production line was observed and the effect of construction and setting changes of certain process steps on the yarn quality properties were investigated. For this purpose, carding machine settings, combing materials, sleeve type and size of yarn drawing system, twist level and count of yarns are changed to understand the yarn quality varies. The changing parameters and production steps are presented in Table 1.

Table 1. Experimental Plan

Production Step	Parameters	Levels
Carding	Carding Production Capacity (kg/h)	35 – 45 – 60
Combing	Number of Teeth per cm^2 of Comber	32 – 56 – 97
Ring Frame	Sleeve diameter (mm) of Drawing	28 – 30
Ring Frame	Twist Level (α_e)	4.1 – 4.3 – 4.5
Ring Frame	Yarn Fineness (Ne)	30 – 40 – 50

The yarns observed during production were produced on the Saurer Zinser 351 2Impact FX ring spinning machine. The cotton bales that used in the study were mixed at the same blow room. Trützschler TC03 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 yarn samples in the study were conditioned in a conditioning room at standard atmospheric conditions (20 ± 2°C, 65 ± 2% relative humidity) for 24 h. The fibre properties were measured on High Volume Instruments (HVI) and Uster MN100 Nep controller. Breaking strength and elongation at break properties and hairiness, unevenness and imperfections were measured by using Uster Tensorapid-3 and Uster Tester 4 according to the ASTM D2256 and Uster standards. The obtained results were analysed in 95% confidence interval (α=0.05) using SPSS 23.0 statistical software and by applying variance and Pearson's correlation and regression analyses.

Research Findings and Discussion

Breaking strength and elongation at break properties and hairiness, unevenness and imperfections were determined to understand the effect of construction and setting changes on 100% cotton ring spun yarn quality.

During the carding process, the cleaning rates of the cotton fibers were measured by changing the hourly production capacity of the carding machine. For this purpose, the foreign matter content of the fibers before they entered the carding machine was measured, and then the foreign matter content of the carding band from the carding machine was measured by Uster MN100 nep controller. The difference between the amount of foreign matter at the entrance and the amount of foreign matter at the exit was taken and the clearance rate was calculated by taking the percentage of the remaining difference. The results of the clearance rate of the carding are shown in the Figure 1.

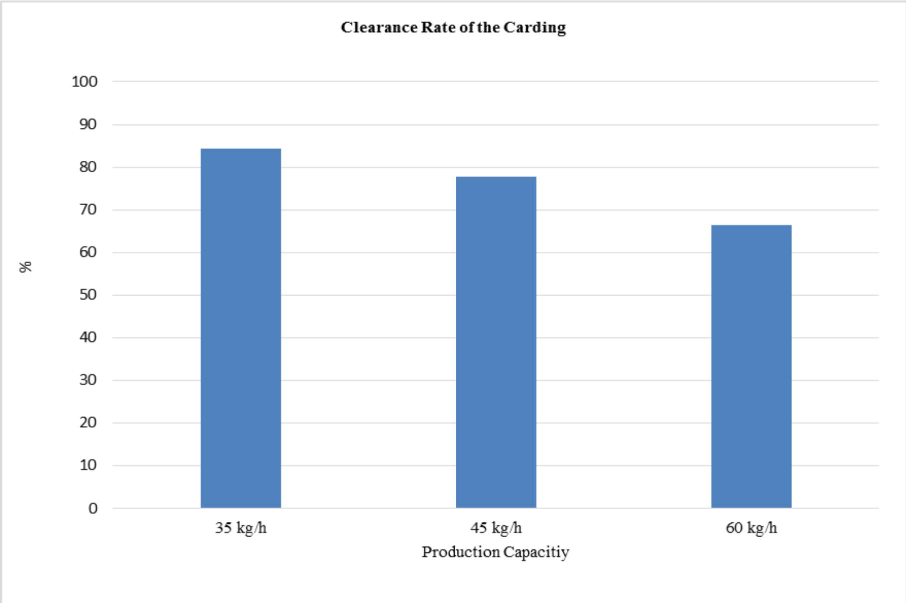

Figure 1. Clearance rate of the carding machine

As seen from the findings, clearance rate of the carding machine decreases with the increase of production rate of the carding machine. As the production capacity of the carding machine is increased, the turnover of the main drum increases and the speed of carding flats decreases. Thus, carding efficiency decreases and the rates of clearance of fibers decrease. It seems reasonable to keep the production capacity around 45 kg/h to avoid disruption of production and decrease in yields. According to the variance analysis, the difference between values are found statistically significant (α<0.05).

Combers with different number of teeth were used in the combing machine, and Ne 50/1 ring spun yarns were produced from these slivers. The effect of the number of teeth of comber on the yarn quality was investigated by comparing the unevenness (CV%), hairiness (H) breaking strength (RKM – kgf/Nm) and elongation at break (E%) values of the produced ring spun yarns. The results of the yarn quality changing according to the combing effect are given in the Figure 2.

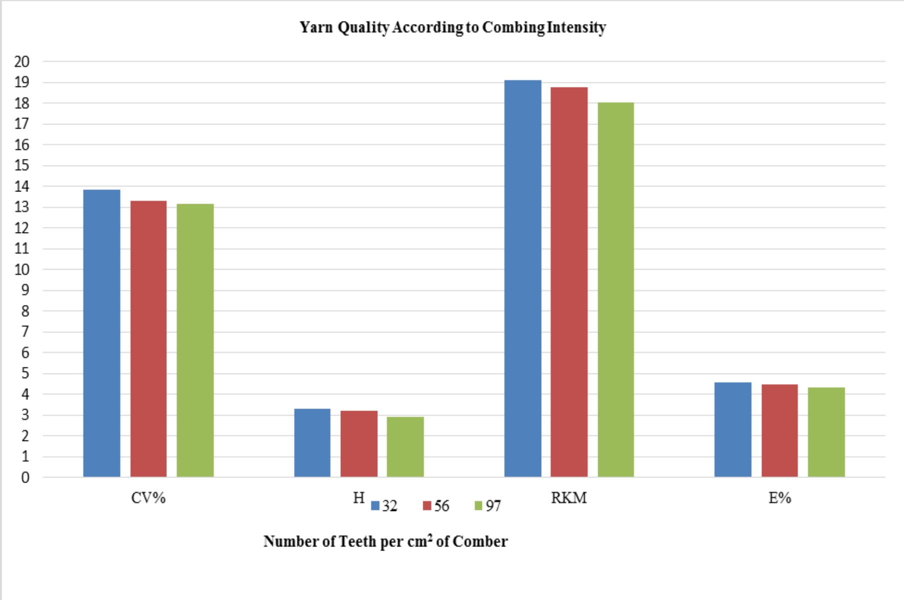

Figure 2. Yarn quality changing according to combing intensity

According to the yarn quality tests, it is observed that the unevenness of the yarns decrease with the increase of the combing intensity, and this effect is found statistically significant (α<0.05). Simlarly, hairiness values of the yarns decrease with the increase of combing intensity, and this effect is found statistically significant (α<0.05). However, when the yarn breaking strength measurement results are taken into consideration, this trend is reversed. As the number of teeth of comber increases, the strength of the yarns produced from these slivers decreases, this effect is also found found statistically significant (α<0.05). The difference between elongation values of the yarns is not found statistically significant (α>0.05). In this case, it can be said that the more effective combing of the fibers during combing process increases the smoothness of the yarns due to the paralleling fibers, while causing a decrease in the strength values due to the hard process.

Ne 40/1 ring spun yarns are produced by changing the diameters of the sleeves used in the drawing frame of the ring spinning machine. Thus, the effects of the change in the diameter of the sleeve on the unevenness (CV%), hairiness (H) breaking strength (RKM – kgf/Nm) and elongation at break (E%) properties of the yarns were investigated. The obtained results can be seen from Figure 3.

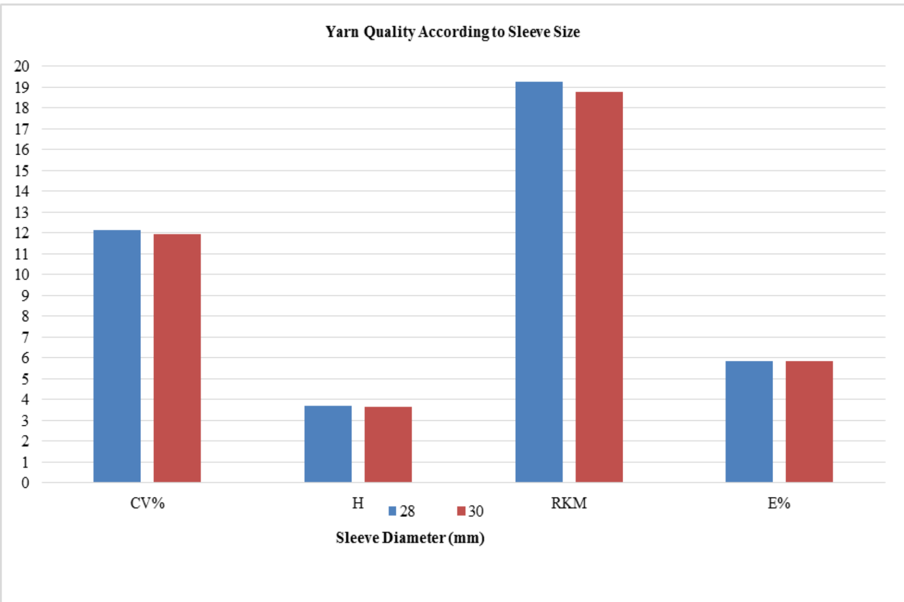

Figure 3. Yarn quality changing according to sleeve size

The measurement results show that, as the sleeve diameter becomes thin (28mm), the yarn unevenness and breaking strength values increase. On the other hand, the elongation and hairiness values of the yarns remain almost the same both sleeve diameters. According to this condition, it can be said that the main effect would be on the yarn unevenness and yarn breaking strength while changing the sleeve diameter or when the sleeves are old.

The yarn twist coefficients (α_e) were systematically changed during Ne 50/1 ring spun yarn production, and the effects of yarn twist level on unevenness (CV%), hairiness (H) breaking strength (RKM – kgf/Nm) and elongation at break (E%) properties of the yarns were investigated. The findings of the experiment are presented in Figure 4.

As seen from the measurement results, the breaking strength of the yarns increases and the elongation values decrease as the yarn twist level increases. The effects of the yarn twist level on the breaking strength and elongation properties are found statistically significant ($\alpha<0.05$). In spite of that, according to the statistical analysis the effects of the yarn twist level on the unevenness and hairiness properties are found statistically insignificant ($\alpha>0.05$). As the twist level is increased, the fibers close to the cross section of the yarn to form a tight structure, and thus, the yarn gets durable but less flexible.

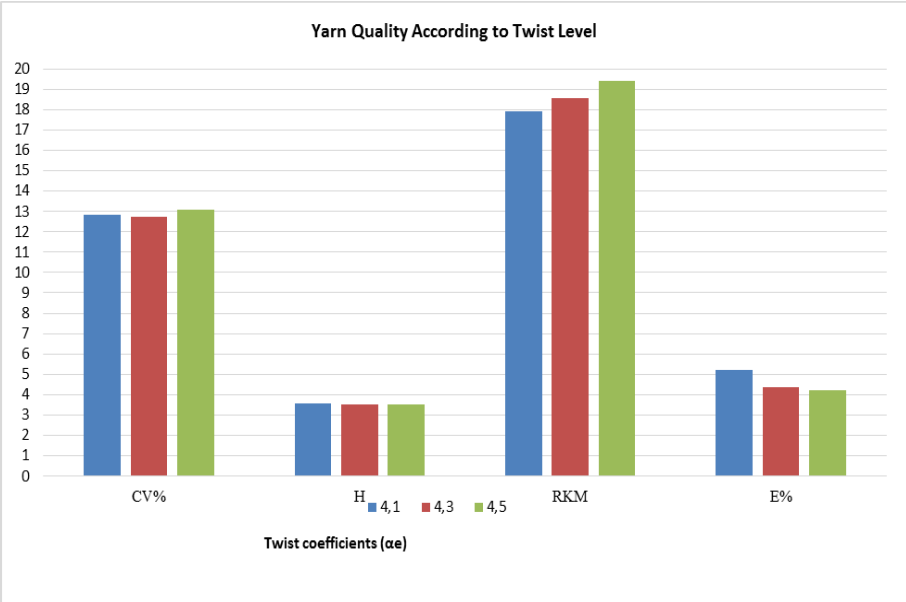

Figure 4. Yarn quality changing according to twist level

Results and Suggestions

In this study, the 100% cotton ring yarn production line was observed and the effect of construction and setting changes of certain process steps on the yarn quality properties were investigated. According to the findings, it may be indicated that the production capacity of the carding machine is increased, the rates of clearance of fibers decrease. But this condition should be taken in account by considering production efficiency and yield. Besides, it may be said that the more effective combing of the fibers during combing process increases the smoothness of the yarns due to the paralleling fibers, while causing a decrease in the strength values due to the hard process. It may also be considered in the production, the main effect of the sleeve diameter would be on the yarn unevenness and yarn breaking strength while changing the sleeve diameter or when the sleeves are old. As the twist level of the yarn is increased, the fibers close to the cross section of the yarn to form a tight structure, and thus, the yarn gets durable but less flexible.

The findings of this study with actual observing of production may be beneficial for cotton yarn manufacturers and engineers who cared about yarn quality with considering yarn parameters.

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Genişletilmiş Özet

Giriş

Ring iplik sistemi 1828'de John Thorp tarafından bulunmuş ve 1830'da sisteme ring kopça, bilezik ve diğer bileşenler eklenerek son halini almıştır [1]. Aradan geçen 170 yıl içerisinde ring iplik makinasında detaylarda bir takım değişiklikler yapılmış, ancak temel konsept aynı kalmıştır. Ring iplik eğirme sistemi, 210 milyon iğ kapasitesi ile dünyadaki iplik eğirme sistemlerinin yaklaşık% 60'ını oluşturmaktadır [2]. Ticari pazara birçok yeni iplik eğirme tekniği sunulmuş olmasına ragmen hiçbiri çok yönlü ring iplik eğirme sistemi gibi kısa lif iplik eğirmeyi etkilememiştir. Ring iplik eğirme tekniğinin popülaritesi yüksek iplik kalitesine, Ne 6 ile Ne 250 arasında geniş bir iplik inceliğinde çalışmasına, bilgi birikiminin oturmuş olmasına, yedek parça ve malzeme ihtiyacının kolay karşılanmasına bağlıdır [3].

Ring iplik eğirme sistemi, harman hallaç, tarak, cer, penye tarama, fitil ve eğirme gibi çok uzun süreçlerden oluşmaktadır. Ring eğirme sistemindeki bu uzun proses adımlarındaki her bir parametre iplik kalitesini önemli ölçüde etkilemektedir. Bu çalışmada ring iplik üretim tesislerindeki bahsedilen uzun iş akışları, proses parametreleri ve kalite özellikleri incelenmiştir. Taraklama parametrelerinin, penye değişkenlerinin, iplik çekme ve büküm ayarlarının şeritlerin ve ipliklerin kalite özelliklerine etkisi gözlenmiştir. Fabrikada devam eden ring iplik üretimindeki gerçek veriler incelenmiş ve üretim ile kalite arasındaki ilişkiler belirlenmiştir.

Yöntem

Bu çalışmada% 100 pamuk ring iplik üretim hattı gözlenmiş ve bazı işlem adımlarının konstrüksiyon ve ayar değişikliklerinin iplik kalitesi özellikleri üzerine etkisi incelenmiştir. Bu amaçla, iplik kalitesindeki değişimleri anlamak için tarak makinesi ayarları, penye makinesi materyalleri, manşon tipi ve iplik çekme sisteminin ölçüleri ve iplik büküm seviyesi değiştirilmiştir.

Üretim sırasında takip edilen iplikler Saurer Zinser 351 2Impact FX ring iplik makinasında üretilmiştir. Çalışmada kullanılan pamuk balyaları aynı harman odasında karıştırılmıştır. Trützschler TC03 tipi tarak makinası kullanılmıştır. Trützschler TD7 ve Trützschler TD8 ile çift pasaj cer işlemi uygulanmıştır. Penye işlemlerinde Rieter E 80 penye makinası, fitil üretimi için Saurer Zinser 670 makinası kullanılmıştır. Çalışmadaki iplik örnekleri, 24 saat boyunca standart atmosfer koşullarında (20 ± 2 ° C,% 65 ± 2 bağıl nemde) kondüsyonlanmıştır. Elyaf özellikleri HVI ve Uster MN100 Nep kontrol cihazında ölçülmüştür. ASTM D2256 ve Uster standartlarına göre Uster Tensorapid-3 ve Uster Tester 4 kullanılarak ipliklerin kopma mukavemeti, kopma uzaması, iplik düzgünsüzlüğü ve iplik tüylülüğü özellikleri ölçülmüştür. Elde edilen sonuçlar % 95 güven aralığında (α = 0.05), SPSS 23.0 istatistik yazılımı ile istatistiksel olarak analiz edilmiştir.

Sonuçlar ve Tartışma

Bu çalışmada % 100 pamuk ring iplik üretim hattı gözlenmiş ve bazı işlem adımlarının konstrüksiyon ve ayar değişikliklerinin iplik kalitesi özellikleri üzerine etkisi incelenmiştir. Bulgulara göre, tarak makinesinin üretim kapasitesinin artırılmasıyla liflerin temizleme oranlarının azaldığı belirlenmiştir. Ancak bu durum üretim verimliliği ve makine randımanları dikkate alınarak düşünülmelidir. Ayrıca, penye işlemi sırasında elyafların daha etkili şekilde taranmasının, paralelleştirme nedeniyle ipliklerin düzgünlüğünü arttırdığı, sert işlemden dolayı mukavemet değerlerinde bir azalmaya neden olduğu görülmüştür. Çekim sistemindeki manşon çapını değiştirirken veya manşonlar eskiyken, manşon çapının ana etkisinin iplik düzgünsüzlüğü ve iplik kopma mukavemeti üzerinde olduğu tespit edilmiştir. İpliğin büküm seviyesi arttıkça, sıkı bir yapı oluşturmak üzere lifler ipliğin enine kesitine daha fazla yaklaşmakta ve böylece iplik mukavim ancak daha az elastikiyete sahip olmaktadır.

Bu çalışmanın gerçek zamanlı üretim gözlemi ile elde edilen bulguları, iplik parametreleri dikkate alınarak iplik kalitesini önemseyen pamuk ipliği üreticileri ve mühendisleri için faydalı olacağı düşünülmektedir.