EVALUATION OF YARN PROPERTIES PRODUCED FROM MECHANICAL COMPACT AND CONVENTIONAL RING SPINNING SYSTEMS

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ABSTRACT:

Fibre ribbon that emerges from the nip of the front drafting rollers in conventional ring spinning is quite wide and converges towards the twist insertion point forming spinning triangle. The attempts to minimise the spinning triangle provided less hairiness with improving yarn quality and tensile results. Fibre compacting systems with modifying apparatuses may be pneumatic or mechanical. Swinsol compact spinning which has a mechanic condensation area is utilized in this study where carded cotton yarn of Ne 12/1, Ne 14/1, Ne 16/1, Ne 20/1 was produced on conventional ring spinning and Swinsol ring spinning systems. The imperfection, hairiness, and yarn tensile values of samples from two groups were compared. Randomised two-factor analysis of variance (two way-ANOVA) was used for determination of the statistical significance of the spinning method and yarn count on yarn imperfection, hairiness, and yarn tensile results. Bar graphs and statistical analyse results displayed that minimum hairiness with maximum RKM was found among the samples of Ne 20/1 Swinsol ring spun yarns.

Keywords: *spinning systems, mechanical compact systems, yarn count, yarn properties*

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1. INTRODUCTION

Textile industry is required to meet the consumer demands creating some obligations for the yarn industry to be innovated as well. Although new spinning technologies have been continuing to be introduced to the yarn industry, usage of modifying apparatus in the existing systems have also been carried out to improve yarn quality as well as the fabrics made of those yarns. Hairiness is usually characterised by the amount of fibres protruding out of the compact yarn body. Yarn imperfections and hairiness are the undesired yarn parameters leading to machine stops as well as influencing textile products' properties negatively. The spinning triangle is the region between the nip of delivery rollers and the twisted end of the yarn. In the ring spinning frame, the fibre bundle follows a path between the drafting system and yarn take-up on the cop. This path involves the drafting arrangement, thread guide, balloon control ring and traveller. These elements are arranged at various angles and distances relative to each other. All these distances, inclinations and angles are referred to as the spinning geometry. The spinning geometry has a significant effect on the end breaks, tension conditions, and generation of fly, yarn hairiness and yarn structure [1-7].

The condensation for eliminating the spinning triangle in compact yarn spinning systems may be achieved by mechanical or pneumatic systems. In the pneumatic systems condensation occurs after the drafting procedure before the yarn formation. The fibre flow reaching the spinning triangle is so narrow. All fibres are caught by spinning triangle. In the process, all the fibres from the remaining spinning triangle are collected and fully integrated in the yarn. Rieter® K-44, Suessen® Elite , Zinser and Toyota® RX-240 are well known pneumatic compact spinning systems. Many researchers have focused on the comparison of conventional ring spun yarn properties with compact spun yarn properties or compared yarn properties of different pneumatic compact spinning systems e.g. Rieter, Suessen, Zinser [8-14]. Göktepe et al. conducted a study where properties of yarns from different compact spinning systems mainly used today were compared in terms of quality parameters. They found that the best results from different compact spinning types varied depending on the yarn count range [2]. The second solution for the fibre condensations is mechanical condensation. The condensation of fibre flow may be improved by a mechanical funnel shaped condenser which is located between the aprons and the delivery rollers. The use of condensers provides a very effective condensation effect. Rocos, the rotorcraft compact spinning system, works on the principle of mechanical condensation. In Rocos compact spinning, compact yarn is produced by adding positive nip at the end of the drafting unit. The condenser is held against the bottom front drafting roller by means of a magnet. The operation brings the fibres closer and eliminates the spinning triangle. According to one of the previous research projects, mechanical compact spinning significantly improves the imperfections and reduces its hairiness [15]. Some investigations were also performed related to evaluation of yarn properties of core-spun yarns produced with different spinning methods including mechanical condensation methods [16]. The compacting device COMPACTeasy is another mechanical compacting system which allows real compacting without additional energy consumption thanks to the y-channel in the Compactor [17]. Swinsol mechanical compact apparatus is also one of the latest systems being used in the spinning mills. The yarn products produced from this system is known to be having reduced yarn hairiness, appropriate strength, and elongation properties even with a lesser amount of twist [8].

To the best of our knowledge, there are not many studies related to utilizing of mechanical compact systems in the spinning systems in the literature. It is aimed to reveal the advantages of the ring spun yarns produced from mechanical compact system by comparing their counterparks produced from conventional ring system within this study. Carded yarns of Ne 12/1, Ne14/1, Ne 16/1 and Ne 20/1 produced from Swinsol ring spinning with mechanical condensation and from conventional ring spinning were produced and their evenness, imperfection, hairiness and yarn tensile properties were compared between each other within our study.

2. Material and Method

The mixed cotton was conditioned for 24 hours under 40% relative humidity (RH). Cotton blend constituting the yarn samples were tested under standard atmospheric conditions 20 ± 2 °C and 65% RH) on a High-Volume Instrument (HVI). HVI results of cotton blend are given in Table 1.

Table 1: HVI parameters of cotton blend utilized in the yarn samples

Fiber fineness, (Micronaire)	Fiber mean length, mm	SF (%)	Strength (g/tex)	Elongation (%)	Trash/count TRCNT	Uniformity Ratio (%)	Maturity
5	30.05	6.2	34.44	7.29	141	84.1	0.88

Yarn production was conducted using the processing stages of the carded yarn production line, where cotton fibers were firstly opened and cleaned in a blowroom. After the blowroom, a carding machine was used to produce card slivers, which were then subjected to the 1st drawing machine, 2nd drawing machine, then to a roving machine and finally to Swinsol ring or conventional ring spinning machine. Produced rovings of Ne 1.04 were spun into yarn numbers of Ne 12/1, Ne 14/1, Ne 16/1 and Ne 20/1 in both conventional ring and on the modified Swinsol ring spinning system. All yarn samples of the same yarn count were produced with the same spinning parameters, namely the same twist multiplier, draft, and spindle speed on conventional and on the modified Swinson ring spinning machine. To minimize any possible variation, 6 cops from each compact spinning machine for each yarn count were available to determine their properties. The yarn tests were carried out on Uster Tester 5, Uster Tensorapid 4 by feeding cops of each system in the same order to the testers. The tests were carried out under standard atmospheric conditions, and the samples were conditioned a minimum of 24 hours before the tests. The results were displayed with bar graphs where "R" indicates conventional ring spinning and "S" indicates for Swinsol ring spinning. In order to analyse the spinning method and yarn count on yarn properties, randomized two-factor analysis of variance (two-way ANOVA) was used for the determination of the statistical significance of these two main parameters. The means were compared by means of SNK tests. The value of the significance level (α) selected for all statistical tests in the study was 0.05. The treatment levels were marked in accordance with the mean values and levels marked by a different letter (a, b, c) indicate that they were significantly different.

3. RESULTS AND DISCUSSION

Coefficient of variation of mass *(CVm%)* results are displayed in figure 1 (a). As it is observed, *CVm* results of yarn samples produced on Swinsol ring spinning machine were generally lower than those produced on conventional ring spinning machine except among the samples of Ne 14/1 yarn count. Highest reduction rate (%) for CVm with the occurrence of Swinsol apparatus was observed among the samples at yarn count of Ne 20/1 as 10% whereas minimum CVm reduction (%) was observed among the samples at yarn count of Ne 12/1 as % 0.8. Figure 1 (b) indicates the IPI value which is the cumulative total of the values of thin places (–50%/km), thick places (+50%/km) and neps (+200%/km) values [18-19]. According to figure 1(b), Swinsol ring spun yarns generally revealed lower IPI values compared to those produced from conventional ring spun yarns at all yarn counts except the yarn count of Ne 12/1 where Swinsol ring spun samples provided higher IPI values. The IPI difference between the samples produced from two spinning systems was clearer at the yarn count of Ne 20/1.

Yarn samples produced on modified ring spinning system revealed lower hairiness results (figure 1c). This is an expected result owing to mechanical condensation area of Swinsol ring spinning system providing a more uniform structure with lower hairiness (figure 2). The decrement of yarn hairiness with Swinsol system is more prominent as the yarn gets finer. For example, the hairiness reduction rate is %3 and %4 among the Swinsol yarn samples with Ne 14/1 and Ne 16/1 yarn count where the reduction rate increases to %11 at the yarn count of Ne 20/1. Our results are consistent with Göktepe et al.'s study where they mentioned that the improvements in the yarn such as hairiness due to the existence of compact systems may be observed more clearly at the finer yarn counts [20].

It is observed that Swinsol ring spun yarns have higher RKM (Rupture per kilometer) results compared to conventional ring yarn samples except for those at the yarn count of Ne 12/1 yarns. The mechanical condensation area revealed in figure 2 enhances more uniform fibre alignment, hence creating more compact structures along the yarn.

This is reflected in the RKM results for Swinsol ring spun yarns (figure 1d). The RKM increments in the yarn samples due to utilizing of Swinsol system is more prominent at the yarn count of Ne 16/1 and Ne 20/1 (5 % increment of tensile results among the samples of Ne 16/1 yarn count and 4% increment of tensile results among the samples of Ne 20/1 yarn count). The elongation results revealed the similar trend where the yarn elongation values of Swinsol ring yarns were generally higher than conventional ring yarn samples' elongation results (%) (figure 1 e).

As an additional analyse, two factor analysis of variance (ANOVA) test was conducted to investigate the effect of yarn count and spinning method parameters on the yarn quality parameters such as yarn unevenness values, hairiness, RKM and breaking elongation values of the conventional ring and the Swinsol ring spun yarns (table 2). According to ANOVA table, yarn count was a significant factor on yarn evenness, IPI, hairiness, and yarn tensile properties ($p \leq 0.05$). Spinning type was a significant factor on yarn evenness values, IPI, hairiness and on elongation (table 2). However, it was a non-significant factor on yarn RKM values ($p>0.05$). Interaction of yarn count and spinning method was also a significant factor on yarn evenness, IPI, hairiness, RKM and on the breaking elongation values ($p \leq 0.05$).

SNK results revealed that CVm results of yarn samples of different yarn counts possessed statistically different values at significance level of 0.05 (table 3). Table 3 indicates that; minimum mass variation values were obtained from Ne 12/1 yarns whereas maximum values were obtained from samples at Ne 20/1 yarn count. It can be concluded that unevenness of the samples gets worse as the yarns got finer. The same trend was observed for IPI results as well. However, hairiness improved as the yarn got finer where Ne 20/1 yarn revealed the minimum hairiness value. RKM values of Ne 20/1 yarn count revealed the maximum value where Ne 12/1 and Ne 14/1 yarn count samples revealed the minimum value which were observed under the same subset at significance level of 0.05. The result is consistent with the bar graphs as well (figure 1 d).

There was an increment trend for breaking elongation values as the yarns got finer (table 4). Minimum elongation values were obtained from yarn samples of Ne 16/1 yarn count while maximum yarn elongation values were observed among the samples of Ne 12/1 yarn count and among the samples of Ne 20/1 yarn count which were observed under the same subset at significance level of 0.05 (table 3).

Additionally, there was not a clear trend for the elongation values regarding to spinning type (table 4).

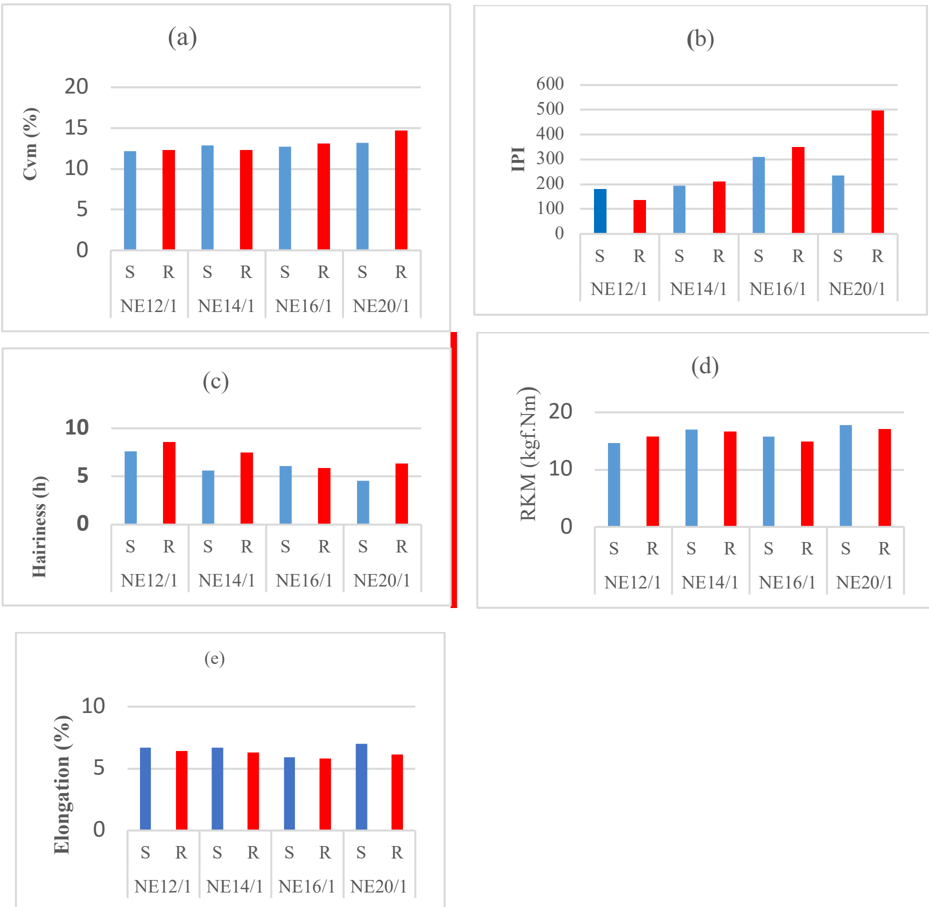
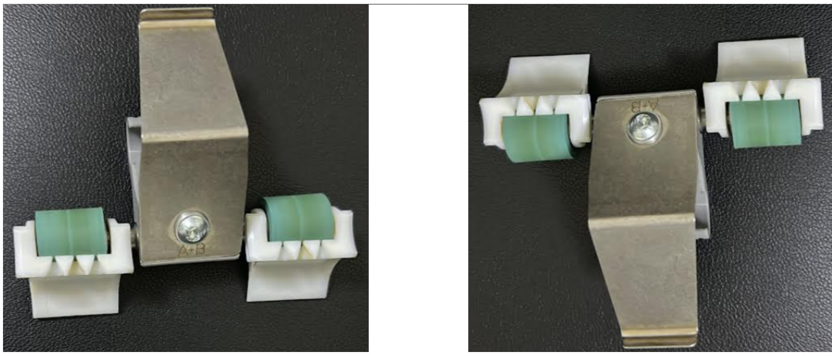


Figure 1: Yarn quality parameters
a: CV_m b: IPI c: hairiness d: RKM e: breaking elongation (%)



(a) **(b)**

Figure 2: (a) Swinsol apparatus front side (b) Swinsol apparatus back side

Table 3: ANOVA results for yarn properties

Main source	CVm	IPI	H	R-km (kgf.Nm)	Elongation (%)
Yarn count (Ne)	0.00*	0.00*	0.00*	0.00*	0.00*
Spinning type	0.00*	0.00*	0.00*	0.33	0.00*
Yarn count* spinning type	0.00*	0.00*	0.00*	0.00*	0.00*

*** significantly important**

Table 4: SNK results for yarn properties

Parameter: Yarn count	CVm	IPI	H	R-km (kgf.Nm)	Elongation (%)
Ne 12/1	12.20 a	158.75 a	8.06 d	15.23 a	6.52 b
Ne 14/1	12.57 b	202.50 a	6.56 c	15.36 a	6.45 b

Ne 16/1	12.91 c	329.79 b	5.97 b	16.78 b	5.82 a
Ne 20/1	13.90 d	359.37 b	5.44 a	17.43 c	6.52 b
Parameter :spinning	**CVm**	**IPI**	**H**	**R-km (kgf.Nm)**	**Elongation (%)**
Conventional ring	13.09 a	297.81 a	6.97 a	16.12 a	6.13 a
Swinsol	12.70 b	227.39 b	5.89 b	16.28 b	6.53 b

The different letters (a,b,c) next to the counts indicate that they are significantly different from each other at a significance level of 0.05

4.CONCLUSION

Yarn quality is one of the main parameters which directly influences the fabric properties. Hence there has always been some attempts for reducing yarn hairiness and yarn imperfections resulting with the improved fabric properties. The aim of this study was mainly built on the comparison of yarn evenness, imperfections and tensile properties produced from modified ring spinning system with mechanical condensation (Swinsol) and from conventional ring spinning. The bar graphs and the two-way ANOVA tests revealed that the results varied regarding to yarn count and to the utilization of mechanical condensation apparatus in Swinsol Ring spinning system. Improvement of yarn unevenness, imperfections and hairiness properties in Swinsol ring spun yarns was observed more clearly at finer yarn counts with the satisfying tensile results. Hence this study may support the idea that utilization of a mechanical condensation in the conventional ring spinning systems has significant influence on yarn evenness and tensile values on positive side.

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