ANALYSIS OF SIROSPUN, PLIED AND SINGLE YARNS PROPERTIES

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Abstract

This study, aimed to determine the differences in the properties of various yarns produced mainly by Sirospun technique and conventional plying process. Regarding the yarn properties, it is found that Siro spinning process is especially better with its tensile properties while conventional plying process attracts attention with mainly lower yarn hairiness and also other yarn properties. Concerning the differences in single and Siro-spun yarn properties, the yarn hairiness was found to be less than singles and plied yarns. Plied yarns are generally stronger and are more extensible and even.

Introduction

Single yarns are generally plied by the conventional method having two stage processes. In conventional plying, the first stage is to assemble two or more single yarns which are wound onto the bobbin and then to twist the assembly around each other with plying/folding process. Therefore, plying can be defined as an expensive process due to the need of the additional twisting. Nowadays, there is more interest in the methods enabling the plied yarn production during the spinning process and eliminating the additional twisting. At the end of many attempts, Sirospun yarn technology was introduced in 1975-1976 by CSIRO (Commonwealth Scientific & Industrial Research Organization), Repco Ltd in combination with IWS (International Wool Secretariat), as an alternative to conventional plying method. Sirospun process combines spinning and doubling in one operation. In Sirospun process, two rovings are led in parallel through the drafting system, separated by two specially developed condensers and then drafted separately. Twist is introduced by means of ring and traveller as for a normal single yarn.

Regarding to the benefits of Siro spinning process, excellent yarn strength, smooth yarn surface and less hairiness has been stated. Many researchers like Gowda et al. (2004), Sun et al. (2000), Cheng et al. (1998) indicated these outstanding yarn properties in their works. In the other studies related to this spinning system, firstly the effect of strand spacing and typical process parameters such as spindle speed, traveller weight on the yarn properties were mostly investigated by Gokarneshan et al. (2007), Gowda et al. (2004), Cheng et al. (1998), Salhotra (1990), Subramaniam et al. (1990). In this work, it is aimed to analyze and compare the yarn properties of Sirospun, conventional plied and single yarns. In addition, the yarn properties of single and plied yarns are also analyzed.

Materials and Methods

Yarn Production

100% cotton combed sirospun yarns of Ne 20/2, Ne 40/2 and Ne 60/2 were produced as they are widely used. And also, single yarns having Ne 20/1, Ne 40/1 and Ne 60/1 yarn counts were spun for the plied yarn production by using the same rovings. The fiber properties are given in Table 1.

Table 1. The Fiber Properties

Properties	Mean Values of Pima Cotton
Staple Length (mm)	33,15
Micronaire	4,16
U.I.	86,7
Strength (g/tex)	39,6
Breaking elongation (%)	5,3
SFI	7,4
+b	12,5

Rd	67
CG	33-2
SCI	188

In Sirospun yarn production, specially designed condenser was used before the middle drafting rollers to separate the double rovings required for the production of yarns. The width of the centre parts of the condenser is about 9 mm which is widely used in cotton spinning. In all the yarn production, it was given importance to select the same twist amount. Therefore, twist multiplier was kept at 3,7 tpi×Ne-1/2 for all the yarn types and yarn counts. The twist amounts are 448 tpm for Ne 20/2, 634 tpm for Ne 40/2 and 780 tpm for Ne 60/2. In Sirospun and single yarn production, 6000 rpm for Ne 20/2 and 10000 rpm spindle speeds for Ne 40/2 and Ne 60/2 yarn counts was used.

For the plied yarn production, single yarns were firstly wound onto the bobbin. Then they were assembled by Fadis doubling machine and then twisted by Savio two-for-one twisting machine. During the twisting process, 8000 rpm spindle speed was used for all the yarn counts. On the other hand, plied yarns are produced as a form of bobbin. Therefore, Sirospun yarns were also wound onto the bobbin and so all the comparisons were done in bobbin form.

Yarn Tests

Yarn tests are carried out on Uster Tester 4, Uster Tensojet and Zweigle G566 testers by feeding the bobbins of each yarn type in the same order to the testers. 3 bobbins were tested for each yarn type. Each bobbin was tested two times for each yarn properties. The tests were carried out under standard atmospheric conditions and the samples were conditioned for 24 hour before the tests.

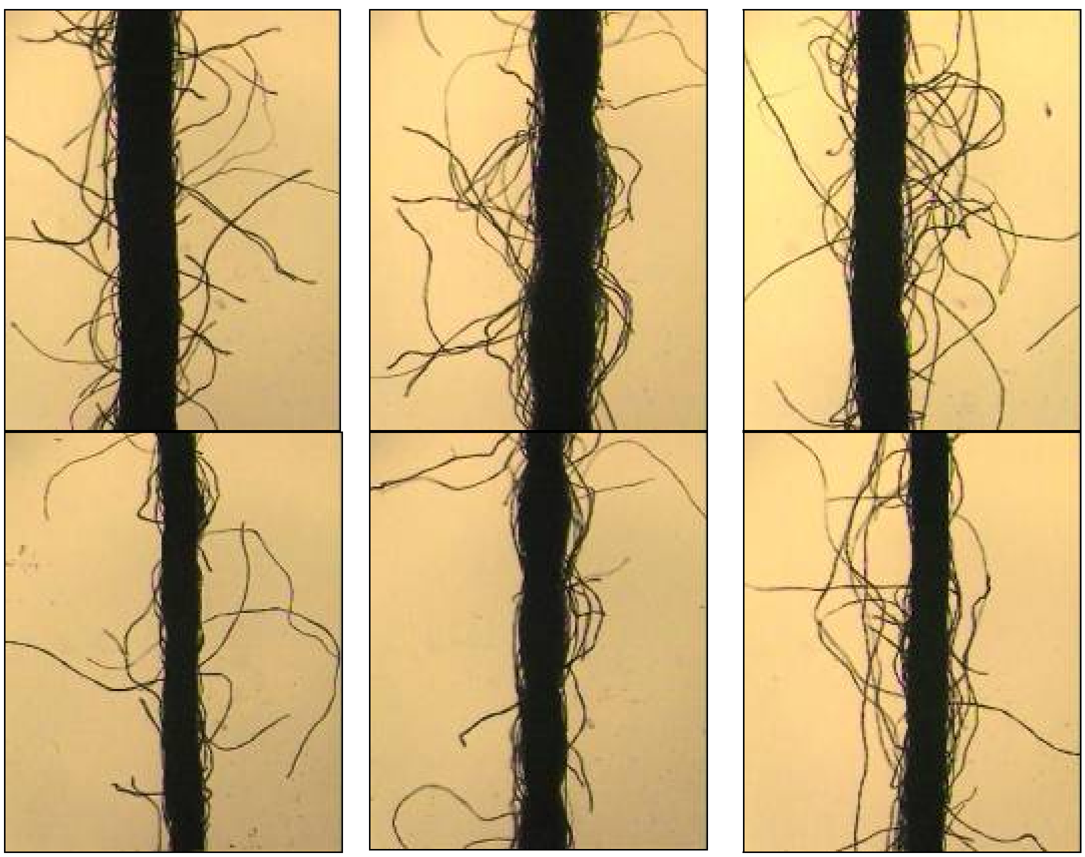
Results & Discussion

Yarn Appearances

The yarn appearance was analyzed under microscope and typical views are shown in Figure 1.

Ne 20/2

Ne 40/2



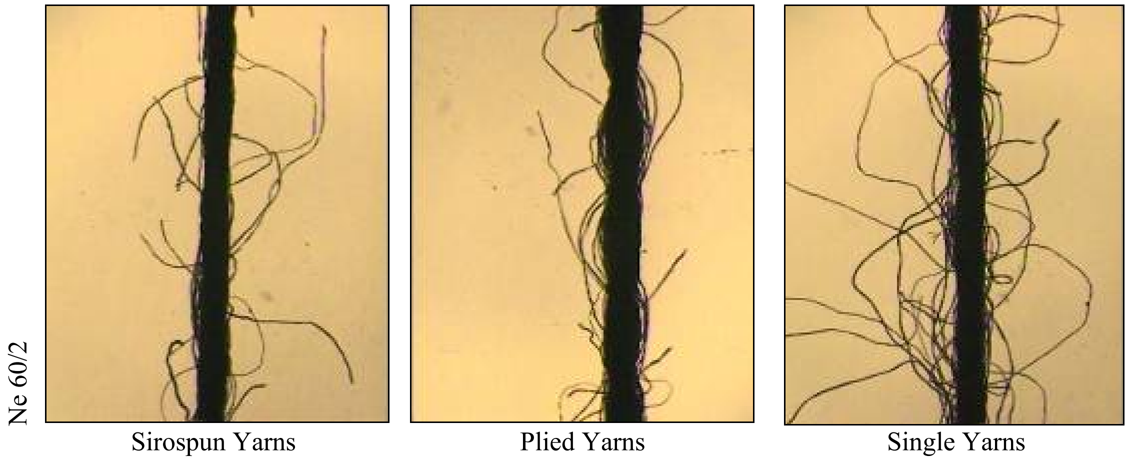


Figure 1. Yarn Appearances (4x)

As it is seen in typical views, all the plied yarns have fewer projected hairs while single yarns have the higher hairs projected from the yarn body causing the yarn hairiness. On the other hand, plied yarns have not a straight yarn structure while single and Sirospun yarns seem as a rod. In the plied yarns, some of the fibers projected from the yarn surface are long while some of them are short due to their loop form. Therefore, longitudinal views of plied yarns appear as curly.

Yarn Hairiness Results

Hairiness results of Sirospun, plied and single yarns are given in Figures 2 & 3.

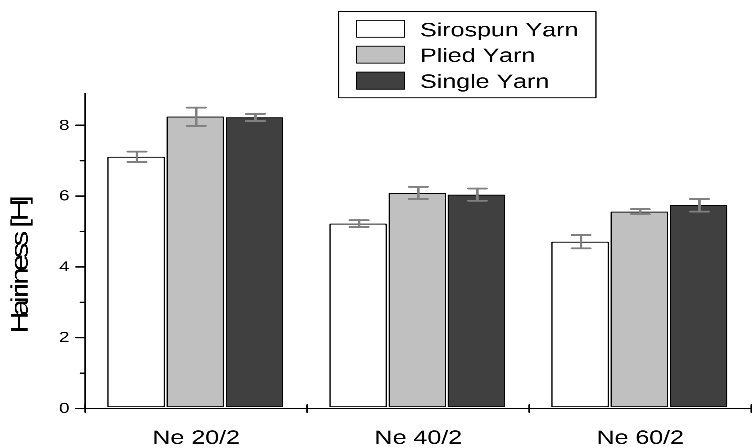


Figure 2. Uster Hairiness (H) Values

According to Uster H values, plied and also single yarns are more hairy than Sirospun yarns for all yarn counts. The difference between Sirospun and other yarns are also statistically significant. On the other hand, plied and single yarns have statistically similar hairiness values.

The Zweigle S3 values are analyzed (Figure 3), it is found that the hairiness values of plied yarns are less while single yarns have the highest S3 values for all yarn counts. Contrary to Uster H results, plied yarns have considerably less hairiness than that of the Sirospun yarns for three yarn counts. Therefore, Uster H results are not in agreement with the Zweigle S3 results. Mainly, the differences in measurement methods of Uster and Zweigle hairiness testers can be the reason for the differences in the results. Another reason can be the differences in number of short hairs of the yarns. To confirm this explanation, it was analyzed for the number of short hairs which was the outputs of Zweigle hairiness tester. For this aim, the number of hairs longer than 1 mm and 2 mm were summed.

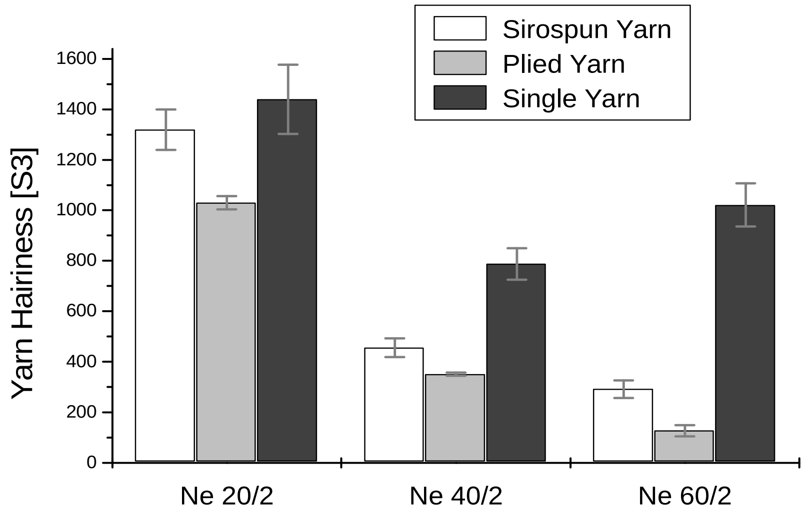


Figure 3. Zweigle Hairiness (S3) Values

The number of short hairs shows that plied yarns have more short hairs compared to that of the Sirospun and single yarns for Ne 20/2 and Ne 40/2 yarn counts (Figure 4). Therefore, Uster H values of plied yarns are higher than that of the Sirospun yarns. On the other hand, in case of Ne 60/2, not only the S3 values but also number of short hairs is lower for plied yarns in comparison to that of the other yarns. Because of the differences in measurement methods, the hairs having loop form of plied yarns (Figure 1) can't be perceived as a long projected hair in Zweigle hairiness tester.

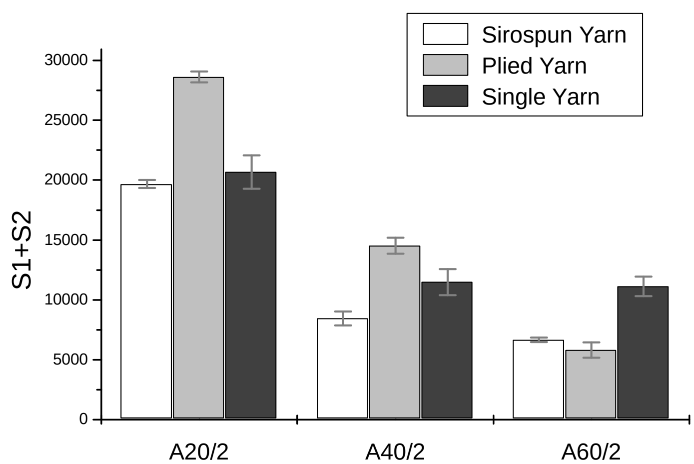


Figure 4. Number of Short Hairs

As a result of hairiness results, it will be true to say that plied yarns have less long hairs than Sirospun and single yarns for all yarn counts. There are initially fewer fiber lengths projecting as hairs from the single yarns and when they are plied, many of hairs are bound into the plied structure as studied by Lord et al. (2003). Hairiness, especially number of long hairs in plied yarns decreases due to binding of some hairs onto the component yarn. This explains the lower number of long hairs in plied yarns.

Yarn Tenacity and Breaking Elongation Results

Tenacity and breaking elongation results are shown in Figures 5 & 6.

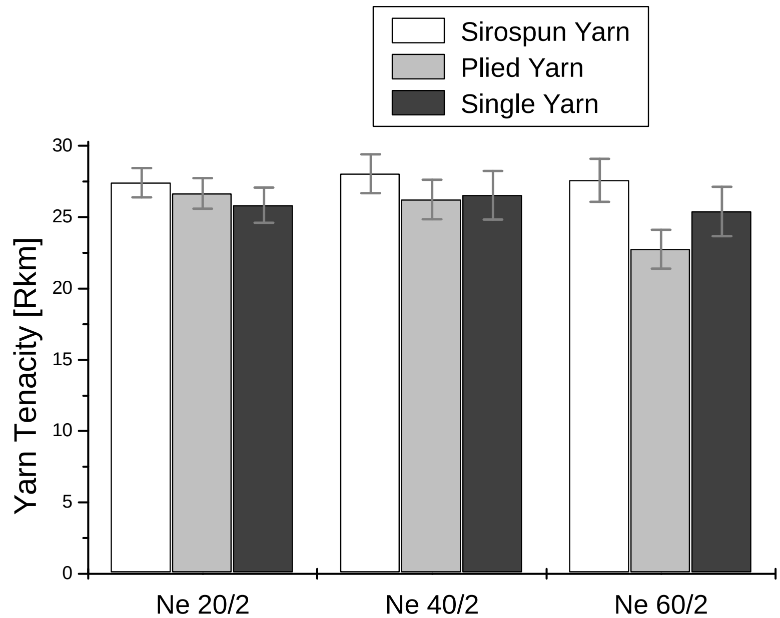


Figure 5. Yarn Tenacity Results

As it is seen in Figure 5, Sirospun yarns have considerably higher yarn tenacity than that of the plied and single yarns for all yarn counts. This results show that sirospun yarns are stronger than plied and single yarns. During the plied yarn production, single yarns pass through winding, assembling/doubling and twisting processes. Therefore, tenacity of plied yarns may decrease because of abrasion during these processes.

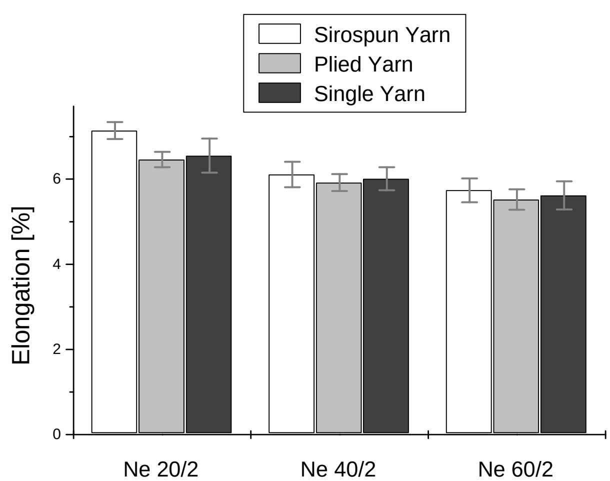


Figure 6. Yarn Elongation Results

Similar to yarn tenacity results, Sirospun yarns are also more extensible than plied and single yarns for all yarn counts, plied yarns are more rigid than the other yarns. On the other hand, there are statistically significant differences between yarn elongation values of Sirospun and other yarns.

In Siro spinning process, two strands converge into a single yarn in terms of the twist propagating from the ring traveller system when they emerge from the drafting system. The variations in spinning tension and also linear density cause a random fluctuation in the twist. Tension fluctuation causes only small imbalances in the tensions at the convergence point and gives only up to 20 turns per meter of strand twist level; Lawrence et al. (2003). With strand and ply twist, fibers are more effectively trapped by every turn of the twist. Trapping mechanism of Siro spinning process increases tensile properties of yarns.

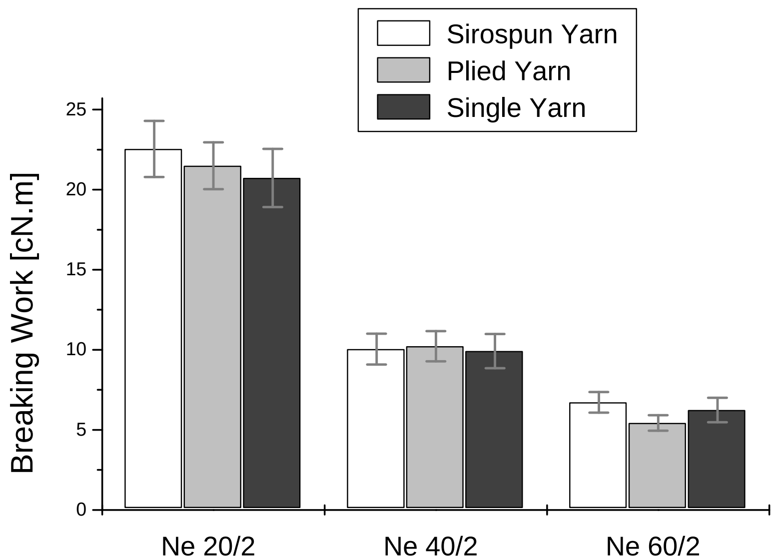


Figure 7. Breaking Work

Due to its higher yarn tenacity and yarn elongation values, Sirospun yarns have higher breaking work values than that of the other yarns for all yarn counts (Figure 7). This result means that it is required more energy to break the Sirospun yarns than that of the other yarns.

Yarn Irregularity Results
Irregularity results of the yarns are given in Figure 8.

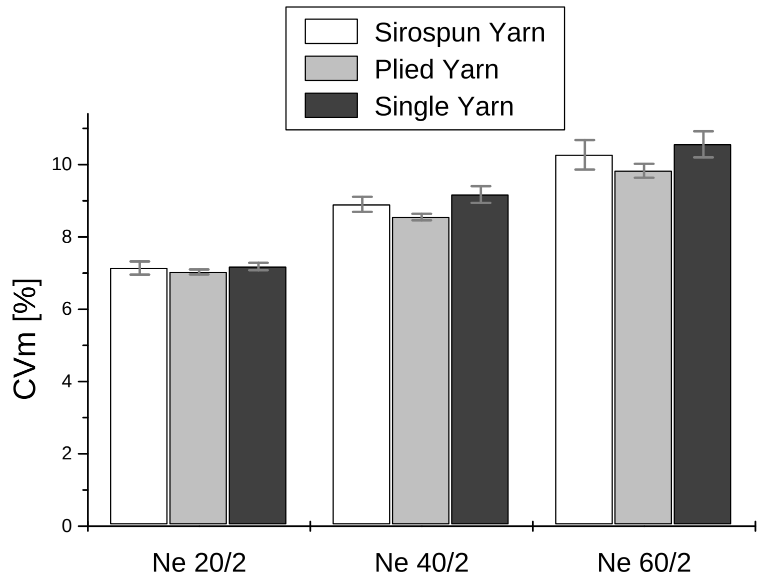


Figure 8. Yarn Irregularity Results

The results indicate that plied yarns have considerably lower yarn irregularity values than that of the Sirospun and single yarns for all yarn counts. In plied yarn production, two or more single yarns are assembled together with assembling/doubling process and then twisted around each other with plying/folding process. In plied yarn production, ply twist direction is usually selected opposite to that of the single yarns. In this study, plied yarns are plied with S on Z twist. Therefore, fibers in the constituent single yarns lie approximately parallel to the plied yarn axis. This may give the plied yarn more smooth and even structure.

Conclusion

In this work, properties of sirospun, conventional plied and single yarns were analyzed. When the Uster H and Zweigle hairiness results were analyzed together, it was found that plied yarns have lower number of long hairs than Sirospun and single yarns for all yarn counts. On the other hand, contrary to expectations and the findings in the literature, Sirospun yarns have more long hairs than that of the plied yarns while short hairs of Sirospun yarns is lower than that of the plied yarns in most cases. Similar to the findings in the literature, Sirospun yarns are also stronger and more extensible than plied and single yarns for all yarn counts. In Sirospun yarn production, strand and ply twist give rise to the tensile properties of the Sirospun yarns due to trapping of the fibers more effectively. Concerning the differences in single and plied yarn properties, plied yarn production processes such as conventional plying process or Sirospun spinning process enables to produce less hairy, stronger, and more extensible and more even yarns.

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