**Influence of the Distance Between Fiber Guide Notches on the Properties of Multi-Component Siro Yarn in Ring Spinning**

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**Abstract.** This research work focuses on the production of multi-component siro-spun yarn on a ring spinning machine and compares the properties of the resulting compacted yarns. The influence of raw material composition, number of strands, twist coefficient, and the distance between fiber guide notches on the characteristics of multi-component siro yarn was studied. It was determined that the effect of raw material on the physical properties of the yarn is statistically significant. Increasing the proportion of polyester in the raw material composition enhanced the yarn's durability, elongation, and strength. Furthermore, it was found that the hairiness of the multi-component siro yarn is better than that of yarns produced by the conventional carded method. It was observed that in the multi-component siro yarn, produced by blending cotton and polyester fibers, the number of thick places exceeded the number of thin places. For this purpose, the properties of Ne 30 multi-component siro yarn, composed of 50% cotton and 50% polyester, were analyzed. The physical-mechanical properties of the produced multi-component siro yarn were investigated. The obtained results indicate that, compared to conventionally carded and compacted yarns, the siro-spun multi-component yarn exhibits lower hairiness and higher breaking strength. Analysis confirmed that the blend ratio, number of fibers, yarn twist coefficient, and the distance between the fiber guides have a statistically significant influence on the yarn properties.

**Keywords:** multi-component, siro yarn, technical textile, fiber, twist, component, compact.

**INTRODUCTION**

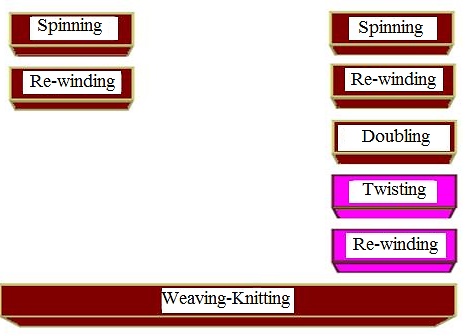
Global practice in recent years has shown a sharp increase in interest in the rational use of production waste, with particular emphasis placed on producing yarn products that allow for the expansion of raw material resources and reduction of the ecological burden on the environment. Goals have been set to further enhance the investment appeal and competitiveness of the textile and garment industry, expand the sector's export potential, and create conditions for wider penetration of local textile products into foreign markets [1].

For the period 2025-2027, key target indicators have been established for developing the processing chain in the textile and garment industry, with the main tasks set to increase product exports to USD 4.0 billion in 2025, USD 5.0 billion in 2026, and USD 7.0 billion in 2027. Through this, the goal is to increase the export of finished products to the markets of the USA and European countries to USD 500 million, raise the share of finished garments in total exports to 70%, and further develop the deep processing of yarn and fabric [2].

The development of the textile industry under market conditions is associated with the improvement of machinery and technology, the application of new achievements in science and engineering to production, increasing process efficiency, and improving final product quality. Improving and automating the ring spinning machine and its main working parts is of particular importance for creating assortments of high-quality yarns with superior physical-mechanical properties, increasing possibilities for producing compacted yarns, researching factors affecting yarn quality, expanding the assortment possibilities through the production of compacted yarns on ring spinning machines, and creating and improving new technologies.

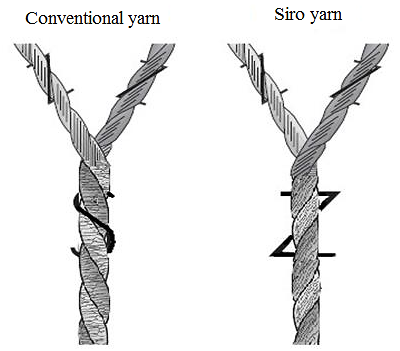
**METHODS**

The quality indicators of conventionally produced plain yarn, its irregularity, elongation at break, and the numerous technological transitions lead to an increase in yarn cost. A somewhat bypassing method is the siro yarn spinning method, which achieves a reduction in technological processes, electrical energy consumption, number of transitions, and labor costs. The technological processes are shown in Figure 1.



**FIGURE 1.** Technological sequence of producing conventional yarn and siro yarn.

Siro-spun yarn is a spinning technology invented by CSIRO (Commonwealth Scientific and Industrial Research Organisation) [2]. Siro yarn entered as a new production method and began to be used for spinning yarn from wool, cotton, and chemical fibers. The production of siro-spun yarn from cotton fibers on ring spinning machines began to be applied in enterprises [3]. Conventional compacted yarns are given a twist direction of ZZ/S, while for siro yarn, SS/S or ZZ/Z twist is applied. Due to the identical twist imparted, the fibers are arranged relatively parallel to each other, achieving reduced yarn hairiness and irregularities, as shown in Figure 2 [4].



**FIGURE 2.** Twist direction of conventional yarn and siro yarn.

Research on comparing the physical-mechanical properties of siro-spun yarn produced by the ring method has been conducted by researchers Mansur and Tawfik, Sun and Cheng, Bedez Üte and Kadaoğlu [5, 6, 7, 8].

Preliminary experimental work was conducted at "Osborn Textile" LLC. During the testing process, in the blending section, an experiment was carried out by blending 50% polyester and 50% cotton fiber from Porlok-2, type 4, grade 1, and 50% cotton fiber of the Sulton variety, type 4, grade 2 [9].

The following machinery was used:

* Automatic bale opener (BDT-019);
* Blending opener for chemical fibers - BOU;
* Opening and blending machine (BOA 012);
* Preliminary cleaning machine (AFC 053);
* Mixing machine (MPM 8);
* Main cleaning machine (CVT 4);
* Aerodynamic cleaning machine (385);
* Carding machine with chute feed (DK 803);
* First passage drawing frame (VOUK-24);
* Second passage drawing frame (HSR-1000);
* Roving frame (ZINSER-660);
* Spinning (on Zinser-351 machine);
* Winding (Autoconer-338);

The brief spinning plan for the cotton-polyester (50/50) blended yarn production at "Osborn Textile" LLC is given in Table 1.

**TABLE 1.** Brief Spinning Plan for 20 tex Cotton-Polyester (50/50) Blended Yarn at "Osborn Textile" LLC

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Name** | **output product linear density (tex)** | **Doubling, d** | **Draft amount, E** | **Twisting amount** | | **Speed of output device** | | **Efficiency factor** | **Theoretical productivity (kg/h)** |
| **αt** | **K, TPM** | **V, m/min** | **n, rpm** |
| **Carding machine**  **C 60** | 5363 | 1 |  |  |  | 165 |  | 0,90 | 60 |
| **Draw frame I**  **SB-D 45** | 5363 | 6 |  |  |  | 500 |  | 0,85 | 150 |
| **Draw frame II RSB-D 35** | 5100 | 8 | 8,36 |  |  | 500 |  | 0,85 | 150 |
| **Roving machine Zinser-668** | 900 | 1 | 5,65 | 8,7 | 29 |  | 1100 | 0,90 | 0,9 |
| **Spinning machine Zinser-350** | 20 | 1 | 45,38 | 32.63 | 730 |  | 15480 | 0,90 | 0,022 |

Based on the brief spinning plan for cotton-polyester (50/50) blended yarn production at "Osborn Textile" LLC, the spinning plan for producing multi-component siro yarn was compiled and is presented in Table 2 [10-13].

Production of Ne 30 multi-component siro-spun yarn was implemented on the Zinser-350 ring spinning machine.

The laboratory of "Osborn Textile" LLC used advanced testing equipment to find out the quality indicators of the multi-component siro yarns that were made during the experiments.

**RESULTS AND DISCUSSION**

Tables and figures show the physical and mechanical parameters of the multi-component siro-spun yarns. These include the yarn count (Ne), the number of twists (T/m), the breaking force (cN/Tex), the unevenness %Cv, the thin areas (-40%), the thick places (+50%), the neps (+200%), the yarn hairiness (H), and the yarn thickness.

The results obtained for the physical-mechanical properties of the produced Ne 30 multi-component siro yarns, with distances between the fiber guide notches of 5 mm and 10 mm, are given in Table 2. The physical-mechanical indicators of the multi-component siro yarn with twist coefficients αe = 3.8 and αe = 4.2 are presented in Table 3.

**TABLE 2. The results obtained for the physical-mechanical properties of the produced Ne 30 multi-component siro yarns, with distances between the fiber guide notches of 5 mm and 10 mm**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Variants observed over one hour** | **Linear density** | **Twists per strand** | **Number of breaks** | **Ends down for different guide spacings** |
| **5mm** | 20/2 | 65 | 18 | 16 |
| **10mm** | 20/2 | 92 | 10 | 18 |
| **5mm** | 29/2 | 75 | 18 | 27 |
| **10mm** | 29/2 | 140 | 8 | 30 |

**TABLE 3.** Physical-Mechanical Indicators of Multi-Component Siro Yarn (50% Polyester / 50% Cotton, Ne 30)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Yarn Property** | **Guide Spacing 5mm** | | **Guide Spacing 10mm** | |
| 3.8 | 4.2 | 3.8 | 4.2 |
| **Linear Density (Tex)** | 20,54 | 20,24 | 20,39 | 20,38 |
| **Unevenness %Cv** | 3,06 | 2,83 | 3,30 | 3,13 |
| **Twist (TPM)** | 620,28 | 725,26 | 618,99 | 727,97 |
| **Twist Irregularity %Cv** | 0,82 | 1,49 | 1,52 | 1,40 |
| **Tenacity (cN/Tex)** | 24,51 | 24,54 | 24,21 | 25,15 |
| **Tenacity Irregularity %Cv** | 4,09 | 3,76 | 5,35 | 5,87 |
| **Elongation at Break (%)** | 10,70 | 10,96 | 10,85 | 11,12 |
| **Elongation Irregularity %Cv** | 6,71 | 3,87 | 5,35 | 5,13 |
| **Thin Places (-40%)** | 200,00 | 166,75 | 217,75 | 127,25 |
| **Thick Places (+50%)** | 417,45 | 389,75 | 498,20 | 413,00 |
| **Neps (+200%)** | 91,25 | 70,00 | 86,50 | 75,25 |
| **Hairiness (H)** | 5,38 | 4,72 | 5,23 | 4,67 |
| **Yarn Thickness** | 5,60 | 6,04 | 5,63 | 5,87 |
| **Yarn Thickness Irregularity %Cv** | 3,26 | 2,04 | 1,33 | 2,46 |

**CONCLUSION**

This study examined the effects of raw material, strand count, twist coefficient, and the spacing between the notches of the fibre guide on the characteristics of multi-component siro-spun yarn. It was established that the influence of raw material on the physical qualities of the yarn is statistically significant. Increasing the amount of polyester in the raw material made the yarn stronger, more durable, and longer-lasting. It was also revealed that the multi-component siro yarn is hairier than yarns made by the traditional carded procedure. It was noted that in the multi-component siro yarn, created by combining cotton and polyester fibres, the quantity of thick sections exceeded that of thin sections. The results for the physical-mechanical properties of the Ne 30 multi-component siro yarns that were made with fibre guide spacings of 5 mm and 10 mm and twist coefficients of αe=3.8 and αye=4.2 were compared and found to be statistically significant.

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