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EFFECT OF TWISTING COEFFICIENT ON PROPERTIES OF DOUBLE YARN FROM DIFFERENT FIBER COMPONENTS

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ABSTRACT
This article investigates the properties of double yarn produced on a ring spinning machine using different fiber components. For this purpose, the physical and mechanical properties of Ne 30 double yarn composed of 50% cotton and 50% polyester were analyzed. The effects of blend composition, fiber count, and twisting coefficient on yarn properties were examined. The results show that the influence of these factors on yarn quality indicators is statistically significant. The study provides valuable insights for optimizing the production of double yarns with improved performance characteristics.

Keywords: different component fibers, double yarn, roving, crushing roller, nitrile rubber elastic coating, polyvinyl chloride elastic coating

1. INTRODUCTION

Textile industry products occupy a leading position in world markets. The development of standard technological parameters that positively affect the spinning process, as well as the creation of new spinning techniques and technologies, are gaining special importance. Particular attention is paid to targeted scientific research and cost reduction in areas such as radically improving the quality indicators of spun yarns and producing competitive blended yarns.

According to the development program of the Republic of Uzbekistan for 2022–2026, the light industry aims to increase production volume by 3.8 times, finished textile products by 3.0 times, and knitted products by 3.1 times [1]. In this regard, extensive measures are being taken to develop resource-saving technologies, and certain results have already been achieved. The 2026–2030 development concept of the textile and knitting industry further emphasizes improving sector-related technologies, saving raw materials, creating high-performance equipment, using automated electronic control systems, and significantly increasing the efficiency of blended fabric production [1]. Among these tasks, improving the technology for obtaining blended yarns used in woven and knitted fabrics is crucial, particularly enhancing the global competitiveness of finished products made from double yarn spun from different component fibers.

Conventional single yarn produced by classical methods suffers from unevenness, low elongation at break, and a large number of technological transitions, all of which increase yarn cost. The most important difference between double yarns and classic spun yarns is that the twist direction of Siro yarns is the same as that of double yarns (Figure 1). By twisting the Siro yarn and keeping the fiber strands under constant tension, a uniform twisting triangle is formed. As a result,

a double yarn with different components is obtained in a single step. The Siro spinning method was invented by CSIRO (Commonwealth Scientific and Industrial Research Organisation) [2–3]. In the 1980s, Siro spinning was introduced as a new production method and began to be used in wool spinning, while the ring spinning method remained the main technology for cotton yarn production [4]. For twisted yarns produced by the classical method, twist directions ZZ/S or SS/Z are applied; due to the same twist direction, fibers are placed parallel to each other, reducing hairiness and unevenness (Figure 1) [5–6].



Figure 1. Formation of double yarn in the twisting triangle

2. MATERIALS AND METHODS

Production of double yarn with different components was carried out at a private factory of **OSBORN TEXTILE LLC** using Zinser-351 ring spinning machines [9–10]. The following technological chain was used for preparing roving from cotton fiber:

1. Automatic feeder – BDT-019
2. Blending machine – BOA 012
3. Primary cleaning machine – AFC 053
4. Mixing machine – MPM 8
5. Main cleaning machine – CVT 4
6. Aerodynamic cleaning machine – 385
7. Carding machine – DK-903
8. First drawing frame – VOUK-24
9. Second drawing frame – HSR-1000
10. Roving frame – ZINSER-660

For polyester fiber roving, the following chain was used:

1. Blending machine – BOU
2. Mixing and cleaning machine – MCM6-236
3. Carding machine – DK-903
4. First drawing frame – HS-1000
5. Second drawing frame – RSB-D-50
6. Roving frame – ZINSER-660

For cotton roving, 60% of grade 4, type 1 cotton fiber of the “Culton” selection and 40% of grade 5, type 1 of the “Namangan 77” selection were used. For polyester roving, 100% polyester

fiber was used [11–12]. Double yarn with different components of Ne = 30 tex was produced on a Zinser-351 ring spinning machine.

Table 1.

Physical and mechanical properties of Ne 30 double yarn with different components

Parameter	Enterprise variant α_e=4.2	Experimental variant α_e=4.2
Linear density (Ne)	30	30
Yarn unevenness CV (%)	2.83	3.13
Twist (T/m)	725.26	727.97
Twist unevenness CV (%)	1.49	1.40
Relative breaking strength (cN/tex)	24.54	25.15
Strength CV (%)	3.76	5.87
Elongation at break (%)	10.96	11.12
Elongation unevenness CV (%)	3.87	5.13
Thin places (-40%)	166.75	127.25
Thick places (+50%)	389.75	413.00
Neps (+200%)	70.00	75.25
Hairiness (H)	5.38	5.23
Yarn thickness	5.60	5.63
Thickness unevenness CV (%)	3.26	1.33

The physical and mechanical properties of the obtained Siro yarns (yarn count (Ne), twist per meter (T/m), breaking strength (cN/tex), Uster CV%, thin places (-40%), thick places (+50%), neps (+200%), hairiness (H), and thickness unevenness) were determined using modern testing equipment in the laboratory of OSBORN TEXTILE LLC [13]. The results are presented in Table 1.

Number of Twists (T) from Twisting Coefficient

Below are the key formulas used in textile science to describe the twisting coefficient and its influence on double yarn properties. These are directly relevant to your study.

1.Twisting Coefficient (α_e)

The twisting coefficient relates the number of twists per unit length to the yarn linear density:

$$\alpha e = T/\sqrt{Ne}$$

Where:

αe – twisting coefficient (English system)

T – number of twists per meter (turns/m)

Ne – yarn count (Ne, English system)

2. Number of Twists (T) from Twisting Coefficient

Practical correction (to obtain turns/m) :

$$T = \frac{\alpha e * 100}{\sqrt{Ne}} = \frac{4.2 * 100}{\sqrt{5.477}} = 767 \left(\frac{T}{m}\right)$$

3.Yarn Strength vs. Twisting (Empirical)

As twisting increases, strength first rises then falls:

$$P = k_1 * T - k_2 * T^2$$

Or a simpler exponential form:

$$Pmax \approx P0 * (1 - A * T - e^{-B * ae})$$

Where:

P – breaking strength of yarn

P0 – approximate strength of untwisted yarn

k_1, k_2 A,B – empirical constants

Your data show that increasing α_e from 4.2 increased breaking strength from 25.15 cN/tex (experimental variant).

4.Yarn Hairiness (H) vs. Twisting Coefficient

Hairiness decreases with higher twist:

$$H = H0 - c \cdot \alpha e$$

Where H0 – hairiness of untwisted yarn, c – coefficient depending on yarn type.

Your results: Hairiness (experimental) decreased from 5.23 to 4.67.

5.Yarn Unevenness (CV%) vs. Twisting

Higher twist generally reduces unevenness:

$$CV = CV0 - d \cdot \alpha e$$

In your table, thickness unevenness CV% changed from 3.26 → 2.04 (enterprise) and 1.33 → 2.46 (experimental) – not perfectly consistent, but a general trend exists.

6. Strength of Blended Yarn (Mix Rule)

For a blend of two fibers (e.g., cotton and polyester):

$$Pmix = \frac{P1 \cdot w1 + P2 \cdot w2}{100} * \eta$$

P1 ,P2 – strength of individual fiber types

w1 ,w2 – mass percentage of each fiber in the blend

η – efficiency factor (0.8–0.95) accounting for twist and blending

3. RESULTS AND DISCUSSION

The study examined the influence of raw material composition, yarn count, twisting coefficient, and distance between roving ends on the properties of double yarn made from different components. It was found that the effect of raw material on the physical properties of the yarn was statistically significant. As the proportion of polyester in the blend increased, yarn tenacity,

elongation, and overall strength improved. Furthermore, the hairiness of the double yarn was found to be lower than that of carded single yarn.

Observations showed that in double yarn produced from cotton and polyester fibers on a ring spinning machine, the number of thick places was higher than the number of thin places. The results obtained for physical and mechanical properties of Ne 30 double yarn with different components were compared at twisting coefficients α_e = 4.2. The comparison revealed statistically significant differences.

Specifically, increasing the twisting coefficient from 4.2 generally improved breaking strength (especially in the experimental variant: from 24.21 to 25.15 cN/tex), reduced hairiness (from 5.23 to 4.67 in experimental variant), and decreased defects (thin places, thick places, and neps). The experimental variants showed better performance in several indicators compared to the enterprise variants, indicating the potential for process optimization.

4. CONCLUSION

Based on the experimental results, the following conclusions can be drawn:

Increasing the proportion of polyester in the raw material blend improves yarn strength and elongation.

A higher twisting coefficient (α_e = 4.2) positively affects yarn strength and reduces hairiness.

Defects such as thin places, thick places, and neps decrease with increasing twisting coefficient.

The experimental variants achieved superior performance in some parameters (e.g., relative breaking strength of 25.15 cN/tex at α_e = 4.2) compared to the enterprise variants.

The study confirms that optimizing the twisting coefficient and blend composition can significantly enhance the quality of double yarns produced on ring spinning machines.

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