Investigation of Influence of a New Twist Intensifier on the Properties of the Twisted Yarn

Yuldashev Alisher Tursunbayevich¹, Matismailov Saypila Laloshbayevich², Korabayev Sherzod Ahmadjanovich³*, Aripova Shaxlo Raufovna⁴, Matmuratova Kumrixon Raxmanbergan kizi⁵

¹Department of Spinning Technology, Faculty of Technology of the Textile Industry, Tashkent Institute of Textile and Light Industry, Tashkent, Uzbekistan
²Department of Technology of Products of the Textile Industry, Faculty of Light Industry Technology, Namangan Institute of Engineering and Technology, 160115, Namangan, Uzbekistan
³sherzod.korabayev@gmail.com

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Abstract: The article is devoted to the study of the properties of the yarn obtained by the methods of ring and rotor spinning, for twisted yarn, produced on a VTS-09 double twist machine made by Volkmann (Germany). Experiments were carried out on two types of spinning yarns with yarn counts Ne 20/2 and 12/2 in the existing design (control) and the new design, flexible element with equal tension and twist intensifier and compared the effects of the resulting twisted yarn for quality parameters. Mathematical statistical methods (single-factor analysis of variance) were used to assess the quality of twisted yarn. Experiments have shown that the use of a new design nozzle reduces the vibration of the yarn, which leads to a uniform distribution of twists along the length of the twisted yarn, increases its tensile strength and improves the quality of the twisted yarn.

Keywords: cotton, fibre, linear density, CVm %, CV of twist, twisted yarn, single yarn, twisting machine, twist.

1. Introduction

One of the most pressing issues today is the improvement of technology for the production of twisted yarn from cotton yarn, to determine the effect of twisting of yarn from single yarns spun by ring and OE on its unevenness, strength and Twist Multiplier[1, 2]. In spinning yarns, the fibres are not sufficiently bonded to each other, many of which are partly involved in breaking strength [3, 4]. The share of fibres in yarn strength does not exceed 45-50% [5]. Also, the ends of the fibres of the yarn come out, which makes it more hairiness and less resistant to friction [6]. The forces of friction between the fibres determine the degree of use of their destructive force in the yarn [7]. The magnitude of the friction force depends on the magnitude of the normal pressure created by the tension of the fibres when twisting the yarn [8]. On the basis of scientific research, it was determined that a single yarn is not the same in its physical and mechanical properties [9, 10]. To obtain a twisted yarn with a uniform twist, the yarns must have the same tension, the same pitch of the helix where they will be located [11, 12]. With an uneven tension, a weakly stretched yarn can be wound on a tightly stretched yarn, which leads to defects in the twisted yarn - corkscrew [13, 14].

With the above, a new device (nozzle) was created that gives the same tension to the yarn and helps to distribute the twists in order to obtain quality twisted yarns on the twisting machine and the effect of the new device on the quality of the twisted yarns was studied. A feature of the device is the installation of elastic elements on the inner wall of the nozzle, the spherical shape of the ball-bearing surface of the guide tube thread, as well as the uniform distribution of twists during torsion without vibration. This leads to a decrease in the unevenness of the number of twists and an increase in the quality of the twisted yarn [15, 16, 17].

2. Research methodology

Was studied the influence of single yarns spun by the ring and OE methods on the quality of twisted yarns using a new uniform tensioning and twisting device. During the experiment, was used cotton fibre of type 5, I-grade, good grade, selection variety "Ak-Daryo” 5, grown in Uzbekistan.

During the research, single yarns of the count of Ne20 and Ne 12 were spun using Zinser-350 (Germany) spinning and OE BD-330 (Czech Republic) spinning machines. The quality parameters of raw materials are given in Table 1. Also, the quality of cotton fibre meets the requirements of the standard UzDST [18].

Table.1

Indicators of the given raw material
Rewinding of spinning yarn on an Autoconer machine, doubling processes on the cylindrical cone was carried out on a Fadis machine of the firm (Italy). From the added single yarns, yarns twisted were produced on a VTS-09 twisting machine manufactured by Volkmann (Germany).

Before the production of twisted yarns, the quality characteristics of single yarns with a count yarn Ne 20 and Ne 12 were studied [19]. The quality parameters of the obtained single yarns are shown in Table 2.

### Table 2

| T/p | Items                                | Ne 20/1 | Ne 12/1 |
|-----|--------------------------------------|---------|---------|
|     |                                      | Zinser-350 RS | BD-330 OES | Zinser-350 RS | BD-330 OES |
| 1   | Count NE                             | 20,1    | 20,3    | 12,2    | 12,1    |
| 2   | CVm,%                                | 2.2     | 1.6     | 2.0     | 1.8     |
| 3   | Breakingforce, sN                    | 391     | 318     | 695     | 562     |
| 4   | Relative tensile strength, sN / tex  | 13,2    | 10,9    | 13,9    | 11,2    |
| 5   | CV of breaking strength, %           | 10,1    | 9,2     | 9,4     | 8,8     |
| 6   | Elongation,%                         | 5,3     | 6,4     | 6,8     | 7,7     |
| 7   | Number of twist per meter            | 742     | 846     | 604     | 630     |
| 9   | The use of fiber strength in yarn strength | 0,52 | 0,43 | 0,54 | 0,44 |

### 3. Experimental part

As can be seen in Table 2, the yarns spun in two different methods meet the requirements of the normative technical document [20, 21]. The RKM of a yarn obtained from a ring spinning machine is 1.22-1.24 times higher than that of a yarn obtained from an OE spinning machine. Twisting of Ne 20 OE yarn is 14% higher than ring-spun yarn maturing (846 vs. 742 twists/m), Ne 12 OE yarn is 4% higher (630 vs. 604 twists/m), the use of fibre strength in yarn strength in ring spinning the coefficients are 0.52 (Ne 20) and 0.54 (Ne 12), while the OE yarn is 0.43 and 0.44, respectively.

The above is explained by the peculiarity of the method of OE spinning (OES), ie its dependence on the structure of the yarn [22]. During the experiments, the quality characteristics of the twisted yarns in the existing design (control variant) and in the new device (experimental variant) with the addition of two single yarns were compared.

All tests were performed three times in repetition. Physico-mechanical performance of the rope was determined on the STATIMAT-C tester, the coefficient of variation on the twist on the AUTOTWIST COUNTER twist gauge.

### 4. Theoretical part
The comparison of the parameters was performed mainly on the basis of one-factor variance analysis [23]. Experiments were carried out on 3 repetitions of the RKM and of the CV of RKM of the twisted yarns. The results of measuring the RKM of Ne 20/2 (RS, OES) yarns are given in Table 3.

Table 3.
Parameters of Rkm value of the Count Ne 20/2

| Repetitions | Construction of the spindle (factor A) | RS | OES |
|-------------|--------------------------------------|----|-----|
|             | Normal | New | Normal | New |
| 1           | 14.6   | 14.82 | 11.68 | 11.8 |
| 2           | 14.6   | 14.83 | 11.60 | 11.9 |
| 3           | 14.36  | 14.80 | 11.63 | 12.0 |
| Mean        | 14.52  | 14.81 | 11.67 | 11.9 |

The square root value of the Rkm indices

| Repetition | Construction of the spindle (factor A) | RS | OES |
|------------|--------------------------------------|----|-----|
|             | Normal | New | Normal | New |
| 1           | 3.821  | 3.850 | 3.418 | 3.435 |
| 2           | 3.821  | 3.851 | 3.421 | 3.450 |
| 3           | 3.789  | 3.847 | 3.410 | 3.464 |
| $\Sigma^2$ | 43.5565 | 44.4521 | 35.014 | 35.7009 |
| $\Sigma_A$ | 22.979 | 20.598 | |
| $\Sigma_{\Sigma_{\Sigma}}$ | 88.0086 | 70.7149 | |

The sum of the squares was calculated from the following formulas:

$$SS_{total} = \sum_{i=1}^{p} \sum_{j=1}^{m} y_{ij}^2 - \frac{A^2}{mp}$$  \hspace{1cm} (1)

$$SS_a = \sum_{i=1}^{p} A_i^2 - \frac{A^2}{mp}$$  \hspace{1cm} (2)

$$SS_A = SS_{total} - SS_a$$  \hspace{1cm} (3)

Table 5.
Source of dispersion | The sum of the squares | Number of degrees of freedom-f | Average square | Fisher-F criteria |
|----------------------|------------------------|-------------------------------|----------------|-----------------|
| RS                   |                        |                               |                |                 |
| Factor A             | 0.0023                 | 1                             | 0.0023         | 15.3 > 7.71     |
| Error                | 0.0006                 | 4                             | 0.00015        | $F_{\text{tab}}=7.71$ |
| Sum                  | 0.0029                 | 5                             |                |                 |
| OES                  |                        |                               |                |                 |
| Factor A             | 0.0017                 | 1                             | 0.0017         | 22.6 > 7.71     |
| Error                | 0.0003                 | 4                             | 0.000075       | $F_{\text{tab}}=7.71$ |
| Sum                  | 0.0020                 | 5                             |                |                 |

Since 15.3 > 7.71 for spun yarn and 22.6 > 7.71 for OE yarn, a significant difference in RKM is observed for the two constructions of the double-twisting device when spinning in both methods for Ne 20/2 twisted yarn. The advantage of the new design has been proven. The effect of the factor on the CV% on the breaking force is analyzed in Tables 6-8.

Table 6.
Values of the CV% on the RKM of the count Ne 20/2 yarn
Table 7.
The square root values of the CV% on the breaking strength of 20/2 twisted yarn

| Repetition | Construction of the spindle (factor A) | RS | Normal | New | OES | Normal | New |
|------------|----------------------------------------|----|--------|-----|-----|--------|-----|
| 1          |                                        | 9.3| 8.2    | 8.7 | 8.7 | 8.5    | 7.9 |
| 2          |                                        | 8.9| 8.7    | 8.3 | 8.3 | 8.9    | 8.1 |
| 3          |                                        | 8.8| 8.4    |     |     |        |     |
| Mean       |                                        | 9.0| 8.4    | 8.7 | 8.7 | 8.1    |     |

Table 8.
Analysis of the variance of CV% of the yarn count 20/2 (Ring Spun and OE)

| Source of dispersion | The sum of the squares | Number of degrees of freedom | Averagesquare | Fisher-F criteria |
|----------------------|------------------------|------------------------------|---------------|------------------|
| Ring Spinning        |                        |                              |               |                  |
| Factor A             | 0.0155                 | 1                            | 0.0155        | 8.16             |
| Error                | 0.0077                 | 4                            | 0.0019        | F=7.71           |
| Sum                  | 0.0232                 | 5                            |               |                  |
| OE spinning          |                        |                              |               |                  |
| Factor A             | 0.0159                 | 1                            | 0.0159        | 14.45            |
| Error                | 0.0046                 | 4                            | 0.0011        | F=7.71           |
| Sum                  | 0.0205                 | 5                            |               |                  |

Since the ring-spun yarn is 8.16> 7.71 and the OES yarn is 14.45> 7.71, the decrease in yarn unevenness when using a new structural yarn in terms of tensile strength has been proven to be accidental.

The values of the RKM of 20/2 (for RS and OES) yarns developed in different devices are given in Table 9, and the square root values of the tensile strength parameters are given in Table 10.

Table 9.
Rkm value of the Ne 12/2 twisted yarn

| Repetition | Construction of the spindle (factor A) | RS | Normal | New | OES | Normal | New |
|------------|----------------------------------------|----|--------|-----|-----|--------|-----|
| 1          |                                        | 14.66 | 14.88 | 11.6 | 11.96 |
| 2          |                                        | 14.60 | 14.92 | 11.7 | 11.98 |
| 3          |                                        | 14.60 | 15.2  | 11.62| 12.0  |
| Mean       |                                        | 14.62 | 15.0  | 11.64| 11.98 |

Table 10.
Square root values of tensile strength parameters
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| Repetition | Construction of the spindle (factor A) |  |  |
|------------|--------------------------------------|-----------------|-----------------|
|            | RS                                   | Normal | New | Normal | New |
| 1          | 3.829                                | 3.857   | 3.406 | 3.458  |
| 2          | 3.821                                | 3.863   | 3.421 | 3.461  |
| 3          | 3.821                                | 3.899   | 3.409 | 3.464  |
| A         | 11.471                               | 11.619  | 10.236 | 10.383 |
| $\sum^2$  | 43,8612                              | 45,0013 | 34,9252 | 35,9354 |

\[
\sum_{i} \sum_{j} y_{ij} = 88,8625
\]

\[
\sum_{i} \sum_{j} y_{ij}^2 = 70,8606
\]

The analysis of the variance of the coefficient of variation of the 12/2 twisted yarn is given in Table 11.

### Table 11.
Dispersion analysis of the CV% of 12/2 (RS and OES) yarn

| Source of dispersion | The sum of the squares | Number of degrees of freedom-\( f \) | Averagesquare | Fisher-F criteria |
|----------------------|------------------------|--------------------------------------|---------------|------------------|
| RS                   |                         |                                      |               |                  |
| Factor A             | 0.0036                 | 1                                    | 0.0036        | 16.0>7.71        |
| Error Sum            | 0.0009                 | 4                                    | 0.000225      |                  |
|                      | 0.0045                 | 5                                    |               | 7.71             |
| OES                  |                         |                                      |               |                  |
| Factor A             | 0.0025                 | 1                                    | 0.0025        | 10>7.71          |
| Error Sum            | 0.0010                 | 4                                    | 0.00025       |                  |
|                      | 0.0035                 | 5                                    |               | 7.71             |

Since the ring-spun yarn is 16.0> 7.71 and the OE spinning yarn is 10> 7.71, the difference in the relative tensile strength values of the yarns in both methods is not accidental when comparing the yarns in the two designs.

### Table 12.
Values of the coefficient of variation on the breaking strength of Count Ne 12/2 yarn

| Repetition | Construction of the spindle (factor A) |  |  |
|------------|--------------------------------------|-----------------|-----------------|
|            | RS                                   | Normal | New | Normal | New |
| 1          | 7.6                                  | 7.4    | 8.3  | 7.9    |
| 2          | 7.9                                  | 7.0    | 8.0  | 7.8    |
| 3          | 7.9                                  | 7.2    | 8.3  | 7.7    |
| Means      | 7.8                                  | 7.2    | 8.2  | 7.8    |

### Table 13.
The square root values of the coefficient of variation on the tensile strength of count Ne12/2 yarn

| Repetition | Construction of the spindle (factor A) |  |  |
|------------|--------------------------------------|-----------------|-----------------|
|            | RS                                   | Normal | New | Normal | New |
| 1          | 2.757                                | 2.720  | 2.881 | 2.811  |
| 2          | 2.811                                | 2.646  | 2.828 | 2.793  |
| 3          | 2.811                                | 2.683  | 2.881 | 2.775  |
| $\sum^2$  | 8.379                                | 8.049  | 8.59  | 8.379  |
| A         | 23,4044                              | 21,5981 | 24,5977 | 23,4031 |
| $\sum_{i} \sum_{j} y_{ij}^2$ | 16,428 | 16,696 |
| $\sum_{i} \sum_{j} y_{ij}^2$ | 45,0025 | 48,0008 |
Table 14.
Dispersion analysis of the coefficient of variation of 12/2 (RingSpun and OESpinning) yarn

| Source of dispersion | The sum of the squares | Number of degrees of freedom-f | Averagesquare | Fisher-F criteria |
|---------------------|------------------------|-------------------------------|---------------|------------------|
| RS                  |                        |                               |               |                  |
| A factor            | 0.0182                 | 1                             | 0.0182        | 16,25>7.71       |
| Error               | 0.0045                 | 4                             | 0.00112       |                  |
| Sum                 | 0.0227                 | 5                             |               | Fт=7.71          |
| OES                 |                        |                               |               |                  |
| A factor            | 0.0074                 | 1                             | 0.0074        | 13,2>7.71        |
| Error               | 0.0023                 | 4                             | 0.00056       |                  |
| Sum                 | 0.0097                 | 5                             |               | Fт=7.71          |

Due to 16.25> 7.71 for RS yarn and 13.2> 7.71 for OES yarn, it is important to reduce the unevenness of the yarn in terms of tensile strength when using new structural yarn.

The analysis of variance shows that regardless of the method of spinning and count the Ne of a single yarn, the specific tensile strength of the twisted yarn increases and the unevenness decreases when using a new tensile element in a twisting machine, indicating that the design effect is not random.

5. Conclusion

When yarns spun in a different spinning system are twisted, the strength of the yarns increases. It can be seen that the strength of OE spun yarns is relatively lower than the strength obtained by ring spun yarns.

When using the same tensioning and twisting device that twists the elastic element twice in the spinning tube, the vibration of the yarn tension is small, which allows the twists to be evenly distributed along the length of the twisted yarn and improves the quality of the twisted yarn. The CV% of the strength of Ne 20/2 twisted yarn in the production of a new uniform tensioning and twisting device increases from 1.1 to 1.122 (in Ring Spun) and from 1,071 to 1,092 (in OE spinning); Production of Ne 12/2 yarn increases from 1,052 to 1,079 (in RS) and from 1.04 to 1.07 (in OES). The decrease in the CV% of unevenness in breaking strength (Sk / S0) is reduced by 6.6–7.7% (in RS) and by 5–7% (in OES).

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Conflict of interest

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