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THE CHOICE OF METHODS FOR DETERMINATION OF OE-ROTOR YARNS SPECIFIC TWISTING

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There exist essential differences between the mechanical models of twisting ring spun and OE-rotor spun yarns, and the internal structure of these two yarn types.
The twisting of single thread ring spun yarns is determined by standardized methods (the untwisting method, the spanning and differential methods) that give good results. However, due to the specific structure of the OE-rotor yarn these methods, although used in laboratories, do not give reliable results, showing, as a rule, slightly lower twisting values than the real (nominal) one. Therefore, the reference data recommend modified spanning method, the so called Schütz-Queny method.
In this work, compared are the test results of twisting of OE-rotor spun yarns with known "nominal" and "machine" twisting values obtained by use of well known standard procedures and by modified procedures. The test results and the correlative analysis indicate a higher objectivity of the modified procedure.

Key words: *yarn, rotor, twisting, test procedures*

1. INTRODUCTION

The inner structure of the yarn depends on the spinning method, and it determines the typical properties of the yarn. The ring spun yarn is influenced by the torsion energy at the so called "twisting threshold" whereby the strands are twisted so that they are spirally wound along the yarn axis. The outer strands are more tightly twisted than the strands in the core, so the ring spun yarn has a so called "outer twisting" [1-5]. The rotor spun yarn is formed by spinning into an open end the accumulated the fibers in the rotor groove, whereby the core of the yarn, with the most tightly twisted strands, is formed first. The twisting is decreasing towards the outer surface, so much so, that a part of the so called "wild strands" has the opposite twist as compared to the yarn core ("the inner twist") [2-6].

By examining the twisting of some fibers in the inner yarn structure, there can be detected three zones in the yarn cross section differing by the twist intensity, as shown in the diagram given in Figure 1.

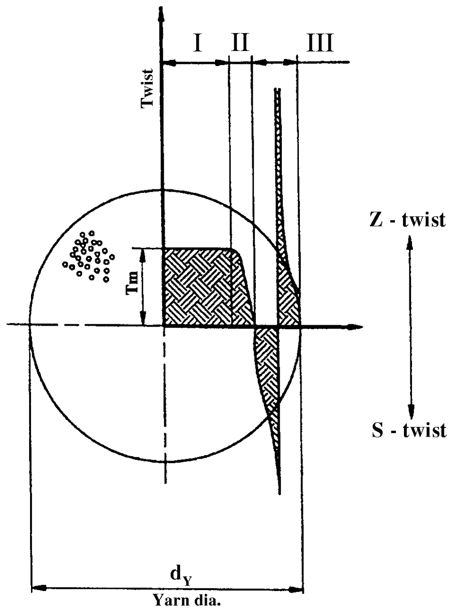

Figure 1. The rotor spun yarn cross section showing twist distribution

- *Zone I* consists of fibers accumulated in the rotor groove beyond the "critical zone", so they were spun as ring spun yarn: with the so called "inner twist". They make the yarn "core" in which all the fibers are twisted in the same direction (in Figure 1 these are Z-twists).

- *Zone II* consists of fibers accumulated at the transport rotor groove output just in the connecting zone (the critical zone). They are wound around the yarn core forming a zone where the twist is loosening towards the outer part reaching the minimum value at the outer surface.

- *Zone III* is formed by the fibers, also accumulated in the connecting zone, whose ends stick out in front of the yarn separation point from the rotor walls (unwinding fibers). They form the outer coating of the yarn with loose connection to the previous layer, being only wound around them [7].

The typical characteristics of rotor spun yarns are greatly influenced by such yarn twisting.

2. MATERIALS AND METHODS

To evaluate the objectivity of the above methods three groups of yarns were used, produced by the same process and from the same cotton fiber type, to avoid the influence of the raw materials on the structural and mechanical properties of the yarns. The yarn samples were made on the AUTOCORO rotor spinning machine, whose characteristics are given in Table1.

Table 1. Technology parameters of rotor spun yarns production

Parameters	Unit	Linear density [tex]		
		20	25	33.33
Rotor rotation speed	min^{-1}	78000	78000	76000
Rotor type		GO.46	GO.46	GO.46
Opening roller rotation speed	min^{-1}	8200	7900	7700
Opening roller coating type		OB20DN	OB20DN	OB20DN
Yarn guide type		CK-4 ceramic		
Yarn speed	$m \cdot min^{-1}$	75	80	90

The basic characteristics of the yarns tested (yarn count and the nominal machine twisting) are given in Table 2. The nominal, i.e. machine twisting is obtained from the technological parameters of the yarn production, i.e. by dividing the number of rotor revolutions by the speed of yarn delivery. These parameters vary for yarns with different length weight.

Table 2. The tested yarns' characteristics

Yarn mark	Typical parameters			Composition
	Nm	Tt [tex]	Tm_n [m^{-1}]	
I	50	20	1040	100% Cotton
II	40	25	975	100% Cotton
III	30	33.33	844.44	100% Cotton

Untwisting Method

By this method, the yarn twisting is determined by simple untwisting of the yarn sample of certain length. The length of single yarns made of staple fibers should be slightly less than the length of the fibers the yarn is made from (25 mm), while the length of the filament fibers and plied yarns can be up to 500 mm.

The number of samples in one test depends on the length of the samples, and in case only one twist is tested, the number of samples should be at least 10.

The samples are placed into a pre-loaded clamp the load of which is determined on the basis of the weight of 500 ± 100 m of the yarn tested, except for the yarn whose stretching under such tension is greater than 0.5%. In that case, the loading should be such that produces stretching less than 0.5 % [8].

Differential or Marschik-Razuvaev Method

According to this method the yarn twist is determined by first twisting the yarn sample until breaking, reading the n_1 value at the moment of breaking. The same procedure is repeated 10 to 20 times in the opposite direction and the value n_2 is read [8]. The number of twists of the yarn tested is determined from the relation:

$$T_m = \frac{n_2 - n_1}{2} \left[m^{-1} \right] \qquad (1)$$

Loading Method

The twist number determination by the loading method is carried out by untwisting the sample to the end and then by further twisting in the same direction until the clamp reads zero. The number of clamp turns registered on the counter is divided by 2. The sample length for all types of yarn can be 500 mm [8].

Modified Loading Schütz-Queny Method

This method consists of three times repeated cycles of untwisting/twisting and calculating the rotor spun yarn twisting from:

$$T_m = \frac{A - 2B + C}{2} \left[m^{-1} \right] \qquad (2)$$

where:

T_m - is the number of twists of OE-rotor spun yarn [m^{-1}],

A - value read on the torsion meter for the first untwisting/twisting cycle, i.e. the first return of the sample into the original state [m^{-1}],

B - value read for the second cycle, the rotation direction of the torsion meter clamp being changed without changing the counter setting [m^{-1}],

C - value read at the third return to the initial length by reverse testing [m^{-1}].

The sample length for all types of yarns can be 500 mm, similar to the loading test method [9].

4. RESULTS AND DISCUSSION

The measurements of the actual yarn twisting were made on “METEFEM” type fy-16/B torsion meter produced in Hungary. The measurements were repeated 15 times for each test method and each yarn length-per-unit weight. The results obtained were statistically processed and the average values of actual twist (Tm_f), standard deviation (SD), and variation coefficient (CV) calculated. These parameters are given in Tables 3, 4 and 5.

Table 3. Twist test results (Tm_f) for yarn I

Test Method	Statistic data		
	Tm_f [m^{-1}]	SD [m^{-1}]	CV [%]
Untwisting method	869.06	53.115	6.112
Differential method	902.33	33.856	3.752
Loading Method	884.46	14.417	1.630
Schütz-Queny	922.40	7.746	0.839

Table 4. Twist test results (Tm_f) for yarn II

Test Method	Statistic data		
	Tm_f [m^{-1}]	SD [m^{-1}]	CV [%]
Untwisting method	719.20	46.307	6.439
Differential method	753.40	32.382	4.242
Loading Method	723.06	20.850	2.884
Schütz-Queny	780.80	11.388	1.508

Table 5. Twist test results (Tm_f) for yarn III

Test Method	Statistic data		
	Tm_f [m^{-1}]	SD [m^{-1}]	CV [%]
Untwisting method	578.40	32.292	5.583
Differential method	627.86	18.661	2.972
Loading Method	581.86	12.964	2.228
Schütz-Queny	632.92	11.285	1.817

The twisting values obtained for the tested rotor spun yarns by all the above methods, as well as the values for nominal or machine determined twisting, are presented graphically in Figure 2. It can be see from this histogram that the values obtained by the Schütz-Queny method were nearest to the machine values, followed by the values obtained by the differential, loading and untwisting method.

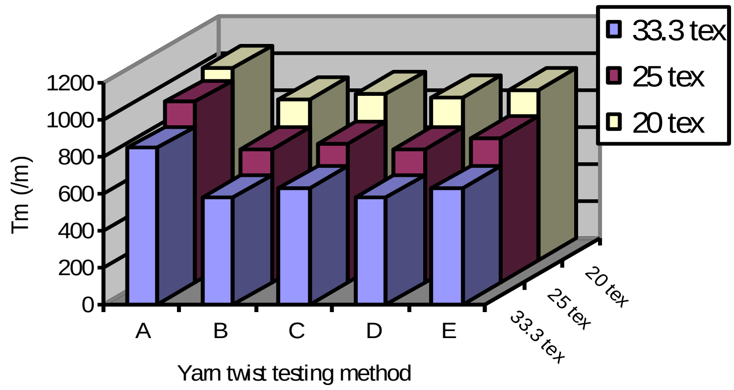

Figure 2. The twisting values for different yarn counts as depending on the test method used
A - nominal (machine) value, B - untwisting method, C - differential method,
D - loading method, E - Schütz-Queny method

From the statistics data given in Tables 3, 4 and 5, it can be seen that the standard deviation and variation coefficient values are the lowest with the Schütz-Queny method for all the yarns tested, and the highest with the untwisting method. This is explained by the fact that the untwisting method is used with yarn samples whose length is slightly less than the staple length (25 mm), and the number of twists is calculated for 1 m yarn length. Thus, a measuring error, made on a 25 mm sample multiplied by 40 obtains larger proportions. Contrary to this, the twisting tests of rotor spun yarns according to other test methods are carried out on samples of 500 mm.

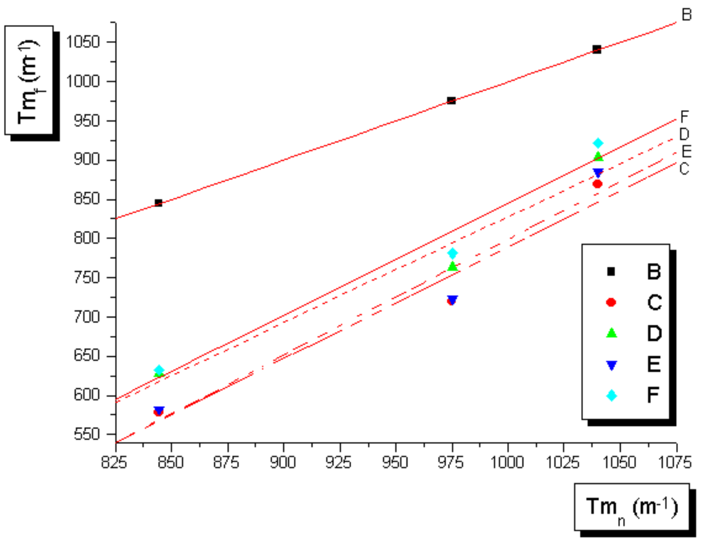

Figure 3. Nominal and actual twisting correlation
B - theoretical regression, C - untwisting method, D - differential method,
E - loading method, F - Schütz-Queny method

The advantage of the Schütz-Queny method compared to the usual twisting determination of the conventional ring spun yarns, is illustrated by the diagram in Figure 3, showing the results of actual twisting test values compared to nominal values, i.e., with respect to the theoretical dependence of nominal and actual twisting.

The test results for the rotor spun yarns tested , representing the average values of 15 repeated measurements on each sample, were mathematically processed and the following form of dependence of actual (Tm_f) and nominal (Tm_n) twisting values of the tested material:

$$Tm_f = a + b \cdot Tm_n \qquad (3)$$

The coefficients of the regression equation (3) “a”, “b” and the correlation coefficient R are given in Table 6.

Table 6. The regression equation coefficients and the correlation coefficients for the test methods used

Regression equation	Twisting test method	Regression coefficients		Correlation coefficient, R
		a	b	
$Tm_f = a + b \cdot Tm_n$	Untwisting method	63.85	0.927	0.97820
	Differential method	52.30	0.850	0.98034
	Loading method	68.12	0.980	0.97373
	Schütz-Queny method	58.45	0.930	0.98408

Based on the data from Table 6 the Schütz-Queny method can be considered suitable for the determination of actual twisting of single rotor spun yarns, because the correlation coefficient is higher by use of this method (98.408%) as compared to the test methods used.

5. CONCLUSIONS

The specific structure of rotor spun yarns makes the testing of their twisting very difficult. Due to a lower degree of looseness and the specific influence of the torsion force, the rotor spun yarns show a bilateral structure consisting of:

- a group of spirally twisted fibers making the core of the yarn, and
- outer fibers, less or more twisted, or even twisted in the opposite direction compared to the fibers in the yarn core [10].

Due to such structure the standard twisting test methods are less objective.

The advantage of the modified Schütz-Queny method compared to the common methods for determination of the twisting of conventional (ring spun) yarns is illustrated in Tables 3, 4 and 5 and the diagram in Figure 2, giving the test results for actual twisting. In all cases, i.e., for all the yarn counts tested, the modified method gave the highest twisting values; these values are nearest to the nominal values. The comparison of standard deviations and the variations coefficients for all the methods used shows that these values were considerably lower for the modified method, which also indicated the objectivity of this method.

On the basis of the test results and the correlative analysis (Figure 3), the modified Schütz-Queny method can be considered as the most appropriate for the determination of the actual twisting of single rotor spun yarns, because the highest correlation coefficient for the regression equation was obtained by the modified method, as given in Table 6.

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