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Compact Cotton Yarn

Abstract
This article presents an analysis and comparison of the parameters of cotton yarn spun on the Fiomax EliTe compact spinning frame from Suessen, and on the PJ 34 conventional ring spinning frame. Combed and carded cotton yarns with linear densities of 15 tex, 18 tex, and 20 tex were manufactured from the same middle staple cotton on both spinning frames, by eliminating 24% of the noils during the combing process. Within the tests carried out, we analysed the following quality parameters of slivers and rovings: the linear density, the mass irregularity, and the tensile strength of the fibre stream (the cohesion strength). We have also assessed and analysed the quality parameters of yarns, such as tenacity, elasticity, mass irregularity, yarn faults, and hairiness. Yarns spun on the EliTe compact spinning frame have the following advantages when compared to those spun on the PJ spinning frame: higher tenacity and elongation at break, lower mass irregularity measured on short segments, and a significantly smaller number of faults such as thin & thick places and neps, as well as a higher degree of elasticity, and a considerably lower hairiness.

Key words: *compact yarn, EliTe, combed yarn, carded yarn, quality parameters.*

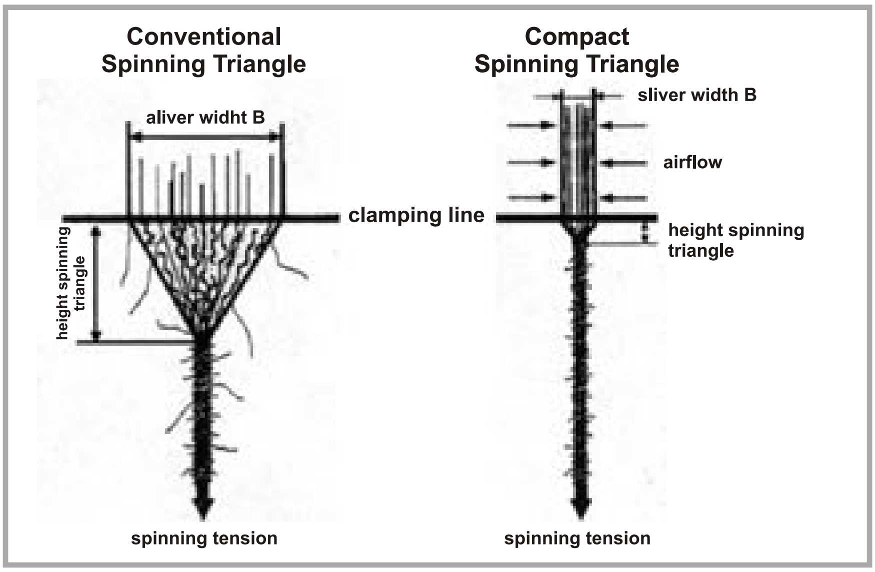

Figure 2. Formation of yarn from fibres after the drawing apparatus [1].

Introduction

Compact spinning systems were first presented at the International Textile Machine Fair ITMA'99. However, investigations into compact spinning have been carried out since 1991, whereas the first spinning frame adapted for compact spinning and dedicated to industrial use were built in 1995. At present, the Rieter, Suessen, and Zinser companies have produced compact ring spinning frames. Over 330,000 spindles of ring spinning frames with the EliTe compact drawing apparatus from Suessen are currently operating in spinning mills [22] all over the world (see Figure 1).

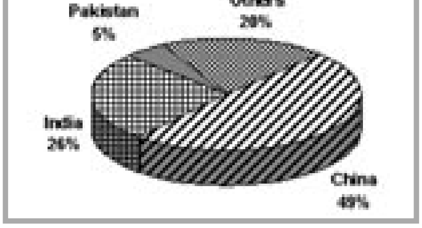

Figure 1. Distribution of EliTe Compactset from Suessen [22].

The aim of applying the compact spinning systems is the increase in yarn quality by means of narrowing and decreasing the width of the band of fibres which come out from the drawing apparatus before it is twisted into yarn, and by the elimination of the twisting triangle.

The 'EliTe' compact system has been incorporated by the Suessen company into a Fiomax-1000 ring spinning frame with drawing apparatus with a three-pair roller. The 'EliTe' system, which is used to pneumatically condense the band of fibres, includes the following elements: feeding rollers, a pair of intermediate rollers encircled by belts, another intermediate pair of rollers, and the delivery roller which works together with a lattice apron. The delivery roller drives the lattice apron, which encircles a profile tube. This tube is under negative pressure. The profile tube is provided with a slot positioned at an incline to the direction of the fibre stream. This causes the fibre stream to change its direction, and so the flat band of fibres is condensed into a compact fibre stream. In addition, the skew position of the slot eliminates the influence of the thickness of the backing on the condensation effect. The condensation zone has its end at the fibres' jamming line between the delivery roller and the lattice apron. This line covers the point at which the twist is initiated, and at the same time causes the elimination of the twisting triangle (Figure 2).

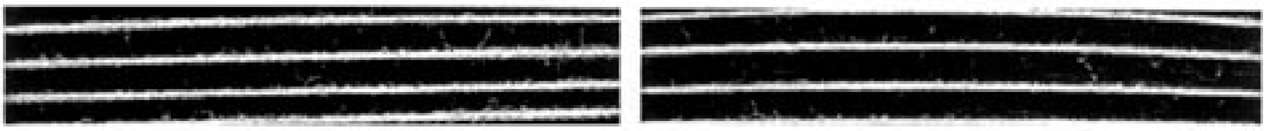

Figure 3. *Yarn appearance [22].*

Research work into the structure of compact yarns and into spinning frame development has been carried out not only by the Suessen company, but also by other machine makers such as Rieter and Zinser [2,3,18,21,35].

From industrial tests and investigation carried out in experimental stations [6,11,13,14,19,21,23-27], it results that the following principal advantages of spinning by means of the compact system can be presented:
- smaller yarn breakage (by 30-60%) during the spinning process (as well as during further processing);
- the possibility of decreasing the twist by 20%;
- higher efficiency connected with higher tensile strength, and with the possibility of spinning with decreased twists of fibres;
- smaller amount of dust released, due to the more compact yarn structure;
- the possibility of increasing the winding and warping velocities;
- the possibility of decreasing the twist by 20% also during twisting yarn on a twisting frame (the yarn structure with lowered twist allows both better dye sorption and lower dye consumption to be obtained).

The following advantages are achieved in weaving:
- reduction of size consumption by 25-50%;
- single and plied yarn do not require singeing;
- lower hairiness and higher tensile strength decreases yarn breakage during warping by 30%;
- a decrease in the number of sized and wedged joints formed over shedding;
- plied yarn can be replaced in the weaving process by the cheaper single yarn;
- warp thread breakage during weaving decreases by 50%, and those of weft by 30%;
- the number of breakages which occur by weft picking on rapier looms decreases by 33%, whereas on pneumatic looms this figure reaches 45%;
- the picking velocity on pneumatic looms can be raised from 500-600 m/min to 700-800 m/min [5,10,11,24].

Yarn manufactured by means of the compact spinning system compared with classical yarn (Figure 3) is characterised by:
- better smoothness,
- higher lustre,
- abrasion fastness better by 40-50%,
- hairiness lower by 20-30%, as measured with the use of the Uster apparatus,
- hairiness lower by 60%, as measured with the use of the Zweigle apparatus,
- tenacity and elongation at break higher by 8-15%, and smaller mass irregularity.

The Aim of Research

Compact yarn is a revolution in spinning technology. Over recent years, the system of compact spinning has constituted a rapidly developing technological trend in most countries. Up to the present, compact yarns belong to unique kind of yarn in Poland. The test results presented in this paper were obtained with the use of the EliTe compact spinning frame from Suessen, the first compact spinning machine operating in Poland.

The aims of the investigation were as follows:
- to determine the process parameters for preparing the streams feeding the compact spinning frame;
- to determine the optimal parameters of the spinning process;
- to compare the yarn parameters obtained with the use of a conventional ring-spinning frame with those obtained by compact spinning;
- to evaluate the new spinning system with the use of the compact ring-spinning frame.

Object of Research and Discussion of Results

We carried out an analysis of the results, and compared the parameters of cotton yarns spun on the Fiomax EliTe ring spinning frame with those on the PJ34 ring spinning frame.

Cotton yarns combed and carded were manufactured on both the compact and the conventional spinning frames. The linear densities of the yarns obtained were 15 tex, 18 tex, and 20 tex. The carded and combed yarns were manufactured from the same middle staple cotton, eliminating 24% of noils during combing.

The tests were carried out at the Wima spinning mill, Łódź, Poland, which uses an EliTe compact spinning frame from Suessen.

Within this research work, the quality parameters of slivers and rovings, such as linear density, mass irregularity, and the stretching strength of the fibre stream (cohesion strength), were determined. While testing the yarns, the following parameters were assessed: tenacity W_w, elongation at break L, degree of elasticity, mass irregularity, yarn faults, and hairiness.

We measured the mass irregularity, the hairiness, and the yarn faults with the use of an Uster Tester 3 apparatus, at a yarn feeding velocity of 400 m/min, and over a 5-minute measuring time span. The results obtained of the analysed yarn parameters were compared with the Uster Statistics [28]. The quality parameters of the analysed sliver and rovings obtained by the tests are presented in Table 1.

Both the slivers and the rovings manufactured from combed cotton are characterised by significantly lower irregularity values for all the length segments analysed. The strength measurements of the analysed slivers were carried out with the use of a F460 Stick-Slip Friction Tester, at the following parameters: drawing ratio 1.5; sliver feeding velocity 5 m/min; pressure 200 kPa (2 bar), and measurement time 30 sec. Five measurements were carried out for every sliver variant.

The strength measurements of the analysed rovings were carried out with the use of a F460 Stick-Slip Friction Tester, at the following parameters: drawing ratio 1.5; sliver feeding velocity 10 m/min; pressure 500 kPa (5 bar), and measurement time 60 sec. Five measurements were carried out for every sliver variant.

The results of the average breaking force F obtained from the F460 Stick-Slip Friction Tester, and the relative tensile strength calculated and designated as the sliver's cohesion strength are presented in Table 2, and the strength parameters of rovings are presented in Table 3.

The fibre stream has a certain strength to stretching due to the cohesion of the fibres. The cohesion of fibres is connected with the physical characteristic of the fibres which form the stream. The type of the fibre material, the fineness ratio, and the surface features all influence cohesion.

The slivers which proceeded from various operations of the technological process differ in their stretching strength. The lowest relative strength (cohesion strength) was exhibited by the sliver manufactured from combed cotton. This result from the considerable straight arrangement of fibres in the sliver, caused by the fibre stretching and paralleling which takes place during the combing process. The cotton slivers were prepared from 1.65 dtex cotton fibres, with 28,280 fibres in the cross-section of the sliver. A comparison of the basic yarn parameters is presented graphically in Figures 4-7.

An analysis and comparison of the quality parameters of combed and carded yarns spun on the conventional PJ34 spinning frame and on the EliTe compact

Table 1. *Quality parameters of cotton slivers and rovings (R½ - carded cotton, Bc - combed cotton).*

Parameter	Unit	Cotton sliver R 1/2	Cotton roving R 1/2	Sliver - cotton combed Bc	Roving - cotton combed Bc
Linear density	ktex	4.54	0.667	4.57	0.667
CVm	%	3.48	5.92	2.54	4.65
CVm [1m]	%	0.64	2.84	0.46	2.32
CVm [3m]	%	0.42	2.55	0.27	1.91
Inert	%	0.56	2.74	0.40	2.14
½ Inert	%	1.26	3.18	0.77	2.67
Index	-	5.78	3.72	4.21	2.91

Table 2. *Strength parameters of slivers obtained by the F460 Stick-Slip Friction Tester (R½ - carded cotton, Bc - combed cotton).*

Successive measurement n	Sliver R 1/2		Sliver Bc	
	Force F, cN	Cohesion strength W, cN/ktex	Force F, cN	Cohesion strength W, cN/ktex
1	160.88	35.43	112.75	24.69
2	164.79	36.29	110.78	24.56
3	157.79	34.75	111.18	24.34
4	155.34	34.21	109.15	23.90
5	154.92	34.12	110.31	24.15
Mean	**158.74**	**34.96**	**110.83**	**24.33**
V	**2.60**	**2.60**	**1.19**	**1.30**

Table 3. *Strength parameters of rovings obtained by the F460 Stick-Slip Friction Tester (R½ - carded cotton, Bc - combed cotton).*

Successive measurement n	Roving R 1/2		Roving Bc	
	Force F, cN	Cohesion strength W, cN/ktex	Force F, cN	Cohesion strength W, cN/ktex
1	161.46	242.07	143.05	214.47
2	155.33	232.88	149.42	224.02
3	158.74	237.99	144.34	216.40
4	159.60	239.28	128.51	192.67
5	163.75	245.50	154.69	231.92
Mean	**159.78**	**239.54**	**144.00**	**215.90**
V	**1.97**	**1.97**	**6.81**	**6.81**

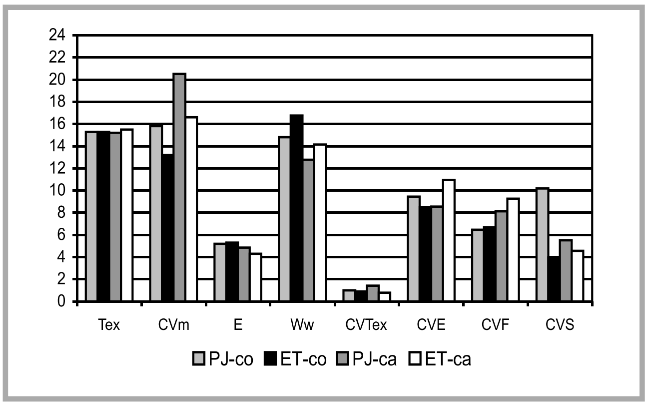

Figure 4. *Parameters of 15 tex yarns from PJ34 and ET - Fiomax EliTe: co - combed, ca - carded, Tex - linear density of yarns; CVm - mass irregularity on short length, %; E - elongation, %; T - tenacity, cN/tex; CVTex; CVE; CVF; CVS, % - coefficient of variation of linear density of yarns, of elongation, of tenacity, of twist.*

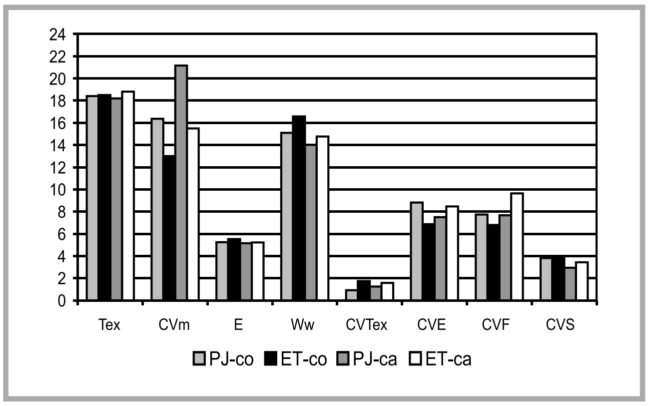

Figure 5. *Parameters of 18 tex yarns from PJ34 and ET - Fiomax EliTe: co - combed, ca - carded, Tex - linear density of yarns; CVm - mass irregularity on short length, %; E - elongation, %; T - tenacity, cN/tex; CVTex; CVE; CVF; CVS, % - coefficient of variation of linear density of yarns, of elongation, of tenacity, of twist.*

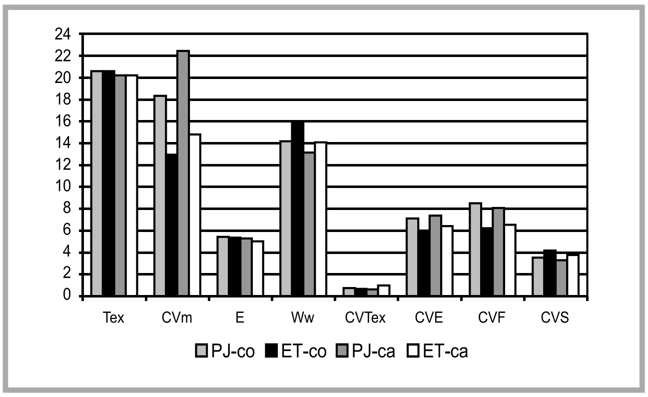

Figure 6. *Parameters of 20 tex yarns from PJ34 and ET - Fiomax EliTe: co - combed, ca - carded.*

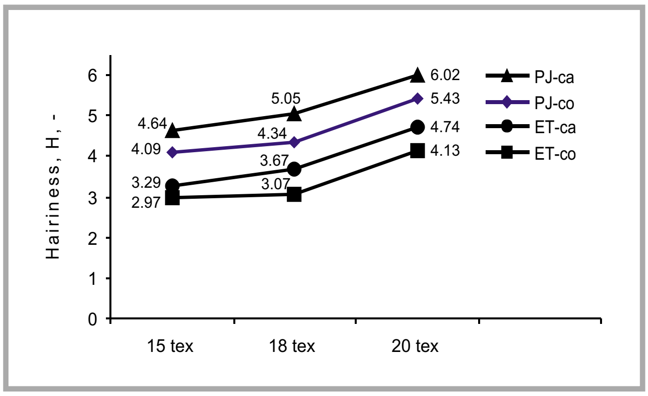

Figure 7. *Hairiness of ring-spun yarns 15, 18, 20 tex acording to Uster: co - combed, ca - carded.*

spinning frame allowed us to draw the following conclusions:

The 15 tex, 18 tex, and 20 tex yarns, both combed and carded, which were spun on the EliTe compact spinning frame are characterised by better quality parameters than the corresponding yarns spun on the PJ34 spinning frame.

The yarns obtained on the EliTe compact spinning frame are characterised by higher tenacity, higher elongation at break, lower mass irregularity measured on short segments, a substantially lower number of faults, such as thin & thick places and neps, a higher elasticity degree, and lower hairiness compared with yarns from the PJ34 spinning frame.

With the increase in linear density of the compact yarns, their mass irregularity decreases, as does the number of faults, whereas the hairiness increases. The combed yarns have a higher tenacity and a lower mass irregularity (by 4%) compared with carded yarns.

The majority of yarn parameters are related to the world level according to the Uster Statistics [28], which allows a quality estimation of the yarns tested. The universality of using Uster Statistics for yarn quality estimation is predominant throughout the world. As the result of comparison of the yarn quality parameters obtained with the Uster Statistics [28] presented in Figures 8 and 9, we can state that the individual parameters assessed by us have reached the following levels of the total world production:

- mass irregularity (coefficient of variation CVm of combed yarn below 5%, and of carded yarn at the level of 25%;
- hairiness for all yarns substantially below 5%.

The yarns with 20 tex linear density were manufactured for knitted fabrics. Preliminary tests were carried out on an open top rib-knitting machine with Nu 18. Knitted fabrics with rib stitch were manufactured within the tests. The knitting process was conducted without any disturbances. On the basis of organoleptic estimation, we could state that the knitted fabrics produced from the yarns spun on the EliTe spinning frames were more regular and smoother, and have a softer and more silky handle, in comparison with the remaining knitted fabrics manufactured from yarns spun on the PJ34 spinning frame.

Summary

- Yarns spun on the EliTe compact spinning frame are characterised by higher tenacity, higher elongation at break, smaller mass irregularity measured at short segments, a significantly smaller number of faults such as thin & thick places and neps, a higher degree of elasticity, and significantly lower hairiness in comparison with yarn from the PJ spinning frame.
- Compact combed yarns have higher tenacity, smaller mass irregularity, and smaller hairiness.
- A comparison between the level of the compact yarn parameters analysed with the Uster Statistics for ring-spun yarns allows us to state that the majority of them placed below 5% or 25% of the world production, which testifies to their high quality.
- The knitted fabrics manufactured from EliTe compact yarns were more regular and smooth, have a soft and

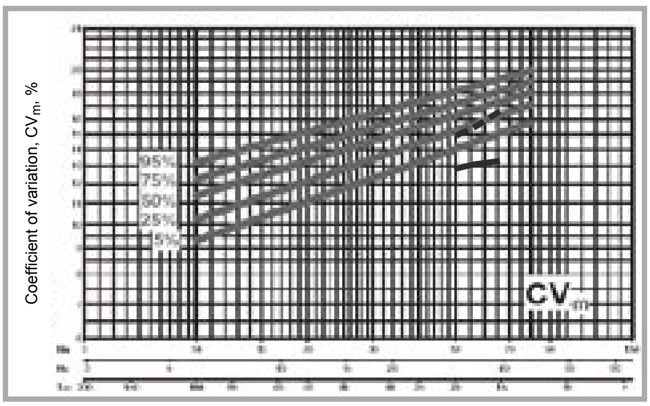

Figure 8. *Uster Statistics 2001 100% CO, carded rotor-spun [28].*

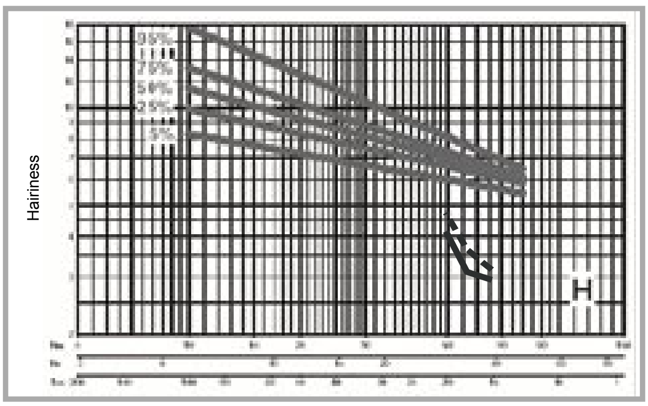

Figure 9. *Uster Statistics 2001 100% CO, carded rotor-spun [28].*

silky handle, and were characterised by smaller pilling than the knitted fabrics from yarns spun on the PJ spinning frame.

Conclusions

- The elongation at break of the EliTe-type yarns has a significantly higher value than that of standard yarn. This feature has an especially good effect in knitting, where elasticity and elongation at break are features of substantial importance.
- The hairiness tests revealed an essential difference between the EliTe and the standard yarn. The compact yarn has a substantially smaller hairiness at a very good world level, below 5% for carded yarns, and likewise for combed yarn. The effect of smaller hairiness of compact yarns can be seen especially clearly in the textiles manufactured from these yarns.
- However, when estimating the yarn parameter improvement, the higher costs of compact yarn manufacture should be considered. The production costs are higher because of the relatively high prices of compact spinning frames, as well as the amortisation costs connected with them. Notwithstanding the high manufacturing costs of compact yarns, their production assures advantage and profit for both the yarn producers and for the customer.

Acknowledgement

This scientific investigation has been financed as a research project by the Polish State Committee for Scientific Research over the years 2004-2006.

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Received 07.04.2004 Reviewed 10.10.2004