

OPTIMIZATION OF THE DRAFTING SYSTEM FOR THE RING SPINNING. PART II

Rodica HARPA, PhD

*Technical University Gheorghe Asachi of Iasi
Faculty of Textile-Leather and Industrial Management
rharpa@tex.tuiasi.ro*

Abstract

Setting of the parameters in drafting zone at the ring spinning frame (roller settings and top arm pressures) have a great impact on the behavior of the fibers in threads and, on the yarn evenness too. This paper reported an experimental study for optimization of the cotton yarn quality depending on the drafting settings by using an original software namely STAT-MFD (Statistical Analysis with MultiFactorial Design)

Keywords: cotton, yarn, drafting system, ring spinning, USTER TESTER 4, factorial design.

INTRODUCTION

Drafting is considered a basic operation in spinning processing and the technological purpose of this operation is decisive in providing evenness to the yarns [1, 2, 3].

The analysis of the factors that may affect the evenness of the linear density of ring spun yarns in actual spinning circumstances is related to the structure and operation of the drafting systems. The lack of correlation of the processed raw material with all these factors it may turn into disturbance that can affect the yarns evenness [4, 5].

In a previous paper [6], the influence of top arm pressure and roller setting for drafting on cotton ring spinning was studied.

In this paper, was assuming another experimental study for approaching the optimization of cotton yarn quality depending on the drafting settings, by using an original software namely STAT-MFD (Statistical Analysis with MultiFactorial Design).

EXPERIMENTAL PART

Previous Work

In a previous paper [6], the influence of top arm pressures and roller settings for drafting on cotton ring spinning was studied. Due to the results obtained in the preliminary experiments, was emphasized the importance

of the adjustments in the SKF-PK 225 drafting systems for the spinning of the 29.4 tex yarn, made from the binary cotton-type mixture 55 % cotton / 45 % Leacryl.

The raw material was assured by three binary mixtures (named R₀₂, R₀₃ and R₀₄) processed from Russian cotton and Leacryl cotton-type into 0.74 ktex roving for ring spun yarns. Unirea FBC ring spinning frame was equipped with 3-line double apron drafting rollers SKF-PK 225 for cotton, man made fibers and cotton type mixtures spinning.

The issue was to apply a multi-factor variance analysis, as a strategy in the assessment of some adjustments influences in drafting system, on the yarn evenness. STAT-ATF software based on the algorithm of the Hierarchical Classification with Three Factors of Variation, was employed for analyzing the experimental results (yarn evenness) depending on several factors that acting at the same time over the threads: rollers loading, opening at apron release point and the hardness of cots.

From the above studies the following conclusion can be drawn: the adequate combination of the shore hardness cots for the rear / front top rollers with load setting on the top rollers and by choosing the gauge aprons depend always on the raw material.

Actual Experiments

The optimization of a technological process through mathematical modeling can be achieved with a mixed factorial experiment. The mixed factorial experiment assures the process design, using some qualitative and quantitative factors, based on the orthogonally property of the considered quantitative factor [7].

The STAT-MFD (Statistical Analysis with MultiFactorial Design) software was achieved on the base of mixed factorial experiment. STAT-MFD software was designed using the Delphi development integrated medium (Inprise Corporation registered trademark) with Pascal and Data Base Engine Paradox and statistical analysis can be made with any available version on 32 bit of the Windows operating system [7].

First of all there been established the quantitative and qualitative experimental factors:

- As *quantitative factors* were established the opening "x" values at the apron release point (between the double aprons), assured by using the gauge clips in the drafting system. The opening at apron release point is considered a quantitative factor, because the upright distance between the front edges of the apron cradle and the bottom apron nose bar determines the intensity of the fibers control in the drafting fields.
- As *qualitative factors* were established the three binary mixtures from Russian cotton and Leacryl cotton type, named R₀₂; R₀₃; R₀₄. From these have been obtained three roving variants with 0.74 ktex and follow-up, processed on the Unirea FBC ring spinning frame.

The preliminary experiments accomplished in the purpose of analyzing the drafting system factors and the influences on the yarn's evenness [6]. It has been established that the adequate distance between aprons, assures the adequate spatial form modification of the fibers mixture in the drafting fields; for top apron cradle OH 62 were available distance clips OLC : yellow (with "x"=2.2

mm), lilac (with "x"=2.5 mm) and white (with "x"=2.9 mm).

Respecting the orthogonally condition for the drafting modeling through mixed factorial experiment, are necessary equidistant and unitary levels for the quantitative factors. Therefore, for the PK 225-SFK 3/3 drafting system with OH-132 top apron cradle [8] have been used SFK original distance clips for suitable to this paper issue: d₁ (red clip) that assures the opening "x"=2.5 mm; d₂ (yellow clip) that assures the opening "x"= 3.3 mm and d₃ (grey clip) that assures the opening "x" = 4.1 mm. Table 1 shows the SFK original distance clips range for OH-132 top apron cradle.

Table 1. SFK statements of the gauge clips range for OH-132 top apron cradle

Symbol Range clips	d ₁	d ₂	d ₃	d ₄	d ₅	d ₆
Color code	red	yellow	lilac	white	grey	black
Opening "x", mm	2,5	3,3	3,3*	3,6	4,1	4,6

The experiments have been accomplished for the combinations of the loads on weighting arms and hardness of cots. This way, for the three binary mixtures (qualitative factors) six experimental variants were employed, each one involving the use of the three clips (quantitative factors), see Table 2.. The experiments codification was the following:

- p₁ (14/10/11)daN, loads settings for combinations of front/rear hardness cots: 75/75 °Sh – experiment 1; 83/75 °Sh – experiment 2 and 83/83 °Sh – experiment 3;
- p₂ (18/10/14)daN, loads settings for combinations of front/rear hardness cots: 75/75 °Sh – experiment 4; 83/75 °Sh – experiment 5 and 83/83 °Sh – experiment 6.

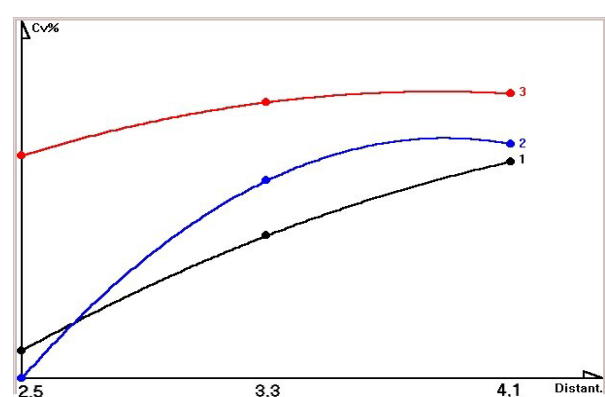
Table 2. Experiments through mixed factorial design

Experimental variants	1			2			3		
Mixture Distance clips	R ₀₂	R ₀₃	R ₀₄	R ₀₂	R ₀₃	R ₀₄	R ₀₂	R ₀₃	R ₀₄
d ₁	10.7	10.73	10.81	10.01	10.58	10.94	11,3	11,73	11,93
	10.52	10.52	10.93	10.37	10.75	10.83	11,62	11,34	11,5
	10.72	10.7	10.63	10.34	10.7	10.75	11,32	11,31	11,79
	10.32	10.55	10.96	10.16	10.62	10.53	11,6	11,76	11,58
d ₂	11.12	11.14	11.5	10.92	11.84	11.35	11,06	12,22	11,97
	11.2	11.13	11.46	11.05	11.91	11.21	11,42	12,5	11,77
	11.08	11.23	11.21	10.93	11.73	11.82	11,18	12,36	11,92
	10.97	11.15	11.19	11.02	12.01	11.6	11,17	12,35	11,76
d ₃	11.44	11.71	11.72	11.15	11.98	11.92	11,08	11,9	12,59
	11.3	11.89	11.25	11.09	11.84	11.51	11,78	11,68	12,22
	11.27	11.85	11.2	11.1	12.02	11.74	11,76	11,67	12,3
	11.29	11.61	11.91	11.14	12	11.91	11,1	11,91	12,17
	4			5			6		
d ₁	11.37	11.72	11.92	10.69	11.05	11.56	11.62	11.84	11.92
	11.15	11.61	11.27	10.94	11.4	10.79	11.51	11.92	11.9
	11.43	11.83	11.58	10.72	11.35	10.96	11.49	11.83	11.94
	11.29	11.59	11.48	10.91	11.1	11.35	11.59	11.81	11.85
d ₂	10.72	10.72	11.34	10.16	10.3	10.31	10.82	11.16	11.18
	10.6	11.28	10.89	10.01	10.21	10.19	10.74	11.07	11.24
	10.22	10.88	11.15	10.06	10.16	10.23	11.01	11.28	11.36
	10.54	10.95	11.18	10.19	10.27	10.26	10.95	11.11	11.26
d ₃	11.84	11.95	11.8	11.55	11.51	11.82	12.39	12.55	12.58
	11.44	11.76	11.94	11.18	12.18	11.3	12.45	12.25	12.88
	11.48	11.93	11.92	11.59	12.12	11.8	12.41	12.52	12.47
	11.81	11.78	11.9	11.14	11.57	11.64	12.43	12.28	12.98

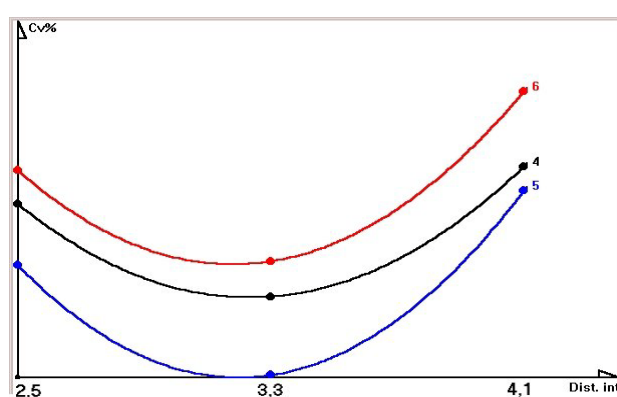
For achieving of the regression equations, was used the variable converted “x” from the actual units (mm) to the variable codified “z” (in unitary values: -1; 0; 1) :

$$z=(x-3.3)/0.8 \quad (1)$$

By returning at the actual values of the quantitative factor ($z \rightarrow x$), were acquired the graphic representations for all the regression equations , see Figure 1.



$$\begin{aligned} \hat{Y}_1(z) &= 11.198 + 0.431 z - 0.093 z^2; \\ \hat{Y}_2(z) &= 11.449 + 0.534 z - 0.367 z^2; \\ \hat{Y}_3(z) &= 11.807 + 0.141 z - 0.101 z^2; \end{aligned}$$



$$\begin{aligned} \hat{Y}_4(z) &= 10.838 + 0.138 z + 0.820 z^2; \\ \hat{Y}_5(z) &= 10.258 + 0.274 z + 1.084 z^2; \\ \hat{Y}_6(z) &= 11.098 + 0.290 z + 0.960 z^2; \end{aligned}$$



a. Experimental variants 1 to 3

b. Experimental variants 4 to 6

Figure 1. Mathematical models and graphics of the regression equations: a.; b.

These represents the mathematical models obtained through the drafting of the roving from the binary mixture, with the qualitative factors of the variation (55% cotton/45% Leacryl recipes spun as R₀₂; R₀₃; R₀₄) and the quantitative factors (the opening at apron release point assured by using three distances clip: d₁, with "x"=2.5mm, d₂ with "x"=3.3mm and d₃ with "x"=4.1mm).

RESULTS

From the above mixed factorial experiments, the following can be drawn:

1. For overall experiments, the regression equations contain for z parameters (which is "the distance between apron cradles"), both linear and square part. Therefore, there are influences of the quantitative factor's variation on the resultant characteristic - the yarn unevenness.
2. The achievement of the 29.4 tex yarns from binary mixtures with the lowest values of the unevenness (CV< 11%) was assured for the three mixtures variants, when the following combinations in the drafting system :
 - very small distance between the apron cradles, $x \rightarrow 2.5$ mm (clips d₁), low pressure on the top rollers (14/10/14)daN, soft cots for rear and front top rollers 75/75⁰Sh (experiment 1) or for the combination 83/75⁰Sh of the hardness cots (experiment 2);
 - medium opening at the apron release point, $x \rightarrow 3.3$ mm (clips d₂), high pressure on top rollers (18/10/14)daN, soft cots for rear and front top rollers 75/75⁰Sh (experiment 4) or combination 83/75⁰Sh of hardness cots (experiment 5).
3. When processing 55% cotton/45%Leacryl mixtures for ring spinning yarns, on PK 225-SFK 3/3 drafting system with two aprons and OH-132 top apron cradle, the efficiency of the drafting requires a small or medium opening at the apron release

point, even at high loads on the top rollers. So, the lowest values of yarn unevenness was achieved by the fibers' control in the "critical space" which was been improved with a reduced spreading of the fibers between top and bottom aprons.

CONCLUSION

Applying the original software STAT-MFD (Statistical Analysis with MultiFactorial Design) elaborated according to the mixed factorial experiment it may assure the technological process optimization (e.g. drafting process) for a large range of raw material (including binary mixture) and for large processing conditions.

In this paper were achieved the mathematical models of the roving's drafting process on the ring spinning frame, for 29.4 tex yarn spun from 55% cotton+45% Leacryl binary mixture.

REFERENCE

- [1] Lord P.R. , Johnson R. , Short Fibres and Quality Control , J.T. I. 1985, nr.3, vol 76, 145-155
- [2] Shaw J. Short –Staple Ring Spinning , T. P. 1982, vol. 12, nr. 2.
- [3] Bona, M., Textile Quality. Physical Methods of Product and Process Control, Textilia–Eurotex, (1994)
- [4] Bona M., Statistical Methods for the Textile Industry, Eurotex-Textilia (1993)
- [5] Uster Technologies, USTER ®Laboratory Systems. Application Manual, (2002)
- [6] Harpa R., Optimization Of Drafting System For Ring Spinning .Part I , Proceedings of International Scientific Conference of Technical University from Gabrovo UNITECH'10- sent for publication.
- [7] Harpa, R., Contributions to the Optimization of the Processing Parameters of Unconventional Cotton Mixtures in Carded Mill, Ph.D.thesis, Iassy, Romania (1999), (in Romanian)
- [8] SKF Textilmaschinen Almanac