

Aspects of the dimensional changes of jersey structures after knitting process

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Abstract. The study proposes a statistical analysis by applying a mathematical model for the study of the dimensional changes of jersey structures made of 100% cotton yarn, with 58/1 metric count of yarn. The Structures are presented as tubular knitted metrage and are designed for underwear and/or outer garments. By analysing the jersey structures, from dimensional stability point of view, there can be observed that values in the limits are within the $\pm 2\%$ interval, values which are considered appropriate. Following the experimental researches, there are proposed solutions for the reduction of dimensional changes on both directions of the knit, on the stitch course direction and also on the stitch courses in vertical direction, being analyzed the behaviour of the knitted fabrics during relaxation after knitting process. The problem of the dimensional stability of the knitted fabrics is extensive researched. The knitted structures are elastic structures, this being a reason for which dimensional stability will always be a topical theme. The jersey structures, due to the distribution of the platinum loop in the knit plane, due to the relative small number of yarn-yarn contact points that causes the threads to slide into the structure, due to the spiral of the tubular metrage structure, are among those whose dimensional stability is difficult to control. The technical characteristics of the yarns, the technical characteristics of the knitting machines and the technological parameters of the knitting machine are the elements which will be correlated in order to obtain structures with minimum dimensional changes. In order to obtain knitted structures with adequate dimensional stability, this means within $\pm 2\%$, it is necessary that the dimensional changes during the relaxation periods after knitting and chemical finishing being minimum. For this, all the processes to be applied will be conducted with appropriate and uniform tensions throughout the technological flow. The relaxation periods of 72 hours should be strictly respected, folded and under standard atmospheric conditions, both after knitting and after chemical finishing. The jersey structures are plane structured made on knitting machines equiped with font. There will be analyzed the dimensional changes of the jersey structures made of 100% cotton yarn, Nm 58/1, after the relaxation after knitting process throughtout the corelation between the technical characteristics of the yarns, of the technological parameter of the knitting operation and of some technical caracteristici of the knitting machine.

1. Introduction

The problem of the dimensional stability of the knitted fabrics is extensive researched. The knitted structures are elastic structures, this being a reason for which dimensional stability will always be a topical theme. The jersey structures, due to the distribution of the platinum loop in the knit plane, due to the relative small number of yarn-yarn contact points that causes the threads to slide into the structure, due to the spiral of the tubular metrage structure, are among those whose dimensional



stability is difficult to control [1]. The technical characteristics of the yarns, the technical characteristics of the knitting machines and the technological parameters of the knitting machine are the elements which will be correlated in order to obtain structures with minimum dimensional changes [2, 3, 6].

In order to obtain knitted structures with adequate dimensional stability, this means within $\pm 2\%$, it is necessary that the dimensional changes during the relaxation periods after knitting and chemical finishing being minimum. For this, all the processes to be applied will be conducted with appropriate and uniform tensions throughout the technological flow [3, 4, 5]. The relaxation periods of 72 hours should be strictly respected, folded and under standard atmospheric conditions, both after knitting and after chemical finishing. During relaxation, the internal tensions introduced into the structures are balanced and the shape of the stitches changes in an absolutely random manner [4, 5, 7].

2. Materials and methods

The jersey structures are plane structured made on knitting machines equipped with font. There will be analyzed the dimensional changes of the jersey structures made of 100% cotton yarn, Nm 58/1, after the relaxation after knitting process throughout the correlation between the technical characteristics of the yarns, of the technological parameter of the knitting operation and of some technical characteristics of the knitting machine.

The knitted fabrics were made on circular knitting machined with large diameter, made by TERROT TIP S-296, the knits obtained being tubular knitt fabric. The technical characteristics of the machine, the type and finess of the yarn are centralized in table no.1.

Table 1. The technical characteristics of the machine.

Type knitting machine	Technical characteristics of the knitting machine				Type of yarn	Metric count of yarn [Nm]	Knit structure
	Needle bar diameter [“]	Finess [E]	Metric count of yarn	Number of needles			
TERROT TIP S-296	30”	28E	96	2640	100% cotton	58/1	jersey

To determine the influence of knitting parameters on dimensional stability, it was established a mathematical model of the correlation between the relaxation shrinkage considered as the dependent variable (response) and the vertical dimension and the speed of the font considered independent variables.

For statistical processing of results, for all knitted structures an experimental program was proposed with two variables x_1 and x_2 constituting the input data. x_1 - represents the wale density on the knitting machine [stitches/cm], and x_2 - turn of the needle bar [rpm]. The proposed program is a mathematically mathematical central rotatable model with two variables. The significance of the coefficients was tested with the T test and the suitability with the Student test. There were determined the coefficients of the regression equations, there were written the equations and graphically represented the response surface for each case as well as the sections through the response surface on the two directions of the knit on the stitch course direction and stitch course in vertical direction. After knitting process, the jersey structures were put in folded position for relaxation 24 hours in standard condition, $T=22\pm 2^\circ\text{C}$, $P=1\text{ atm}=760\text{ mm col Hg}$, $\phi=65\pm 5\%$.

There have been studied the dimensional changes which have appeared after the relaxation process. In table no.2 are represented the encoded and real values for the independent variables, and also the responses for the jersey structure made of 100% cotton yarns, with metric count of yarn 58/1.

Table 2. The encoded and real values.

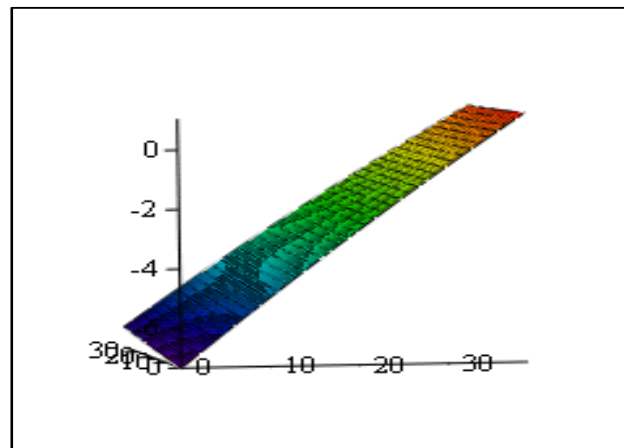
x1 encoded	x2 encoded	Wale density [stitches/cm] (x1 real)	Turn of needle bar [rot/min] (x2 real)	Dimensional changes during relaxation on stitch course direction [%]	Dimensional changes during relaxation on stitch course in vertical direction [%]
-1	-1	9.75	16.31	-5.00	-6.10
1	-1	18.24	16.31	-2.40	-4.20
-1	1	9.75	22.60	-5.20	-6.90
1	1	18.24	22.60	-2.90	-4.90
-1.414	0	8.00	19.50	-7.30	-9.20
1.414	0	20.00	19.50	0.90	-2.60
-1	-1.414	14.00	15.00	-3.40	-6.10
1	1.414	14.00	24.00	-3.90	-5.00
0	0	14.00	19.50	-3.10	-5.40
0	0	14.00	19.50	-3.80	-5.50
0	0	14.00	19.50	-3.20	-5.90
0	0	14.00	19.50	-3.80	-5.80
0	0	14.00	19.50	-3.50	-5.90

Study on the dimensional changes on stitch course direction during relaxation in raw condition for the jersey structures made of 100% cotton with metric count 58/1.

The regression equation which describes the relaxation process of jersey structure made of 100% cotton with metric count 58/1, on stitch course direction is given by the following relation(1):

$$f(x, y) := -3.62 + 2.062 \cdot x + 0.054 \cdot y - 0.052 \cdot x^2 + 0.003685 \cdot y^2 - 0.075 \cdot x \cdot y \quad (1)$$

In figure 1 is presented the response surface, which means dependence $y = f(x_1, x_2)$ in the case of relaxation shrinkage on the stitch course direction of the jersey fabrics studied.

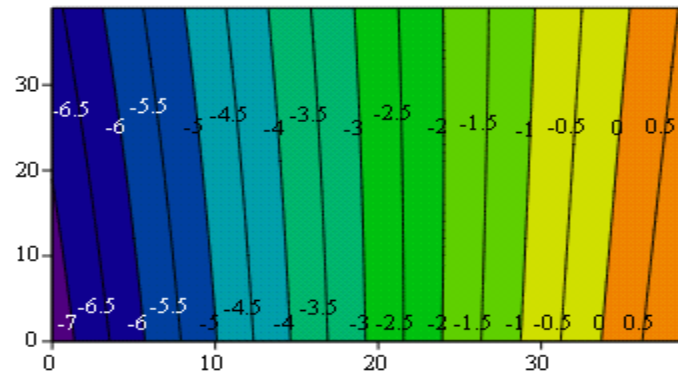


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Figure 1. Response surface in the relaxation shrinkage, on stitch course direction, for the jersey structures made of 100% cotton yarns, Nm 58/1.

By analyzing the response surface represented in fig.1, results the following: The shape of the response surface is a stationary ridge. This is motivated by the fact that one of the coefficients has a very low value.

In figure 2 there are presented the level curves, respectively the sections through the response surface for different levels of relaxation shrinkage.



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Figure 2. Sections through response surface in the relaxation shrinkage, on stitch course direction, for the jersey structures made of 100% cotton yarns, Nm 58/.

From the graphic representation from fig. 2, results that:

- The sections are straight lines, which confirms that the surface of the response is flat;
- The relaxation shrinkage decreases with the increase of the wale density up to the value of 18.5 stitches / cm, after which the decrease continues, the shrinkage being transformed into elongation;
- There is an optimal value of the wale density on the machine and of the turn of the needle bar for which the shrinkage during relaxation in the stitch course direction is zero. This is done at a wale density of around 20 stitches / cm and turn of the needle bar of 20 rotations / min;

In figure 3 is represented the dependence of $y=f(x_1)$ for $x_2=\text{constant}$.

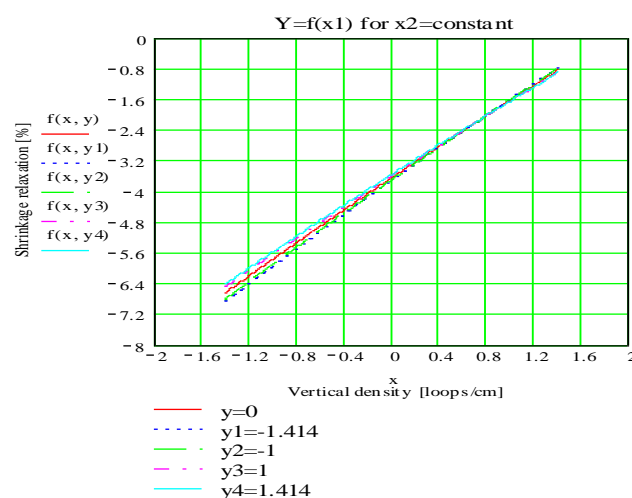


Figure 3. Variation of $y=f(x_1)$ pentru x_2 constant in case of dimensional changes after relaxation, on stitch course direction, for the jersey structures, made of 100% cotton yarns Nm 58/1.

From the graphic analyze from figure3 results that:

- The shrinkage relaxation decreases with the increase of wale density, even if the turn of the needle bar remains constant;
- The influence of the speed of the turn of the needle bar is low on entire range of variation of the wale density
- By the variation of the turn of the needle bar on entire range, it is obtained a contraction change, lower than on the variation of the density on entire range

In figure 4 is represented the dependence $y=f(x_2)$ for x_1 constant.

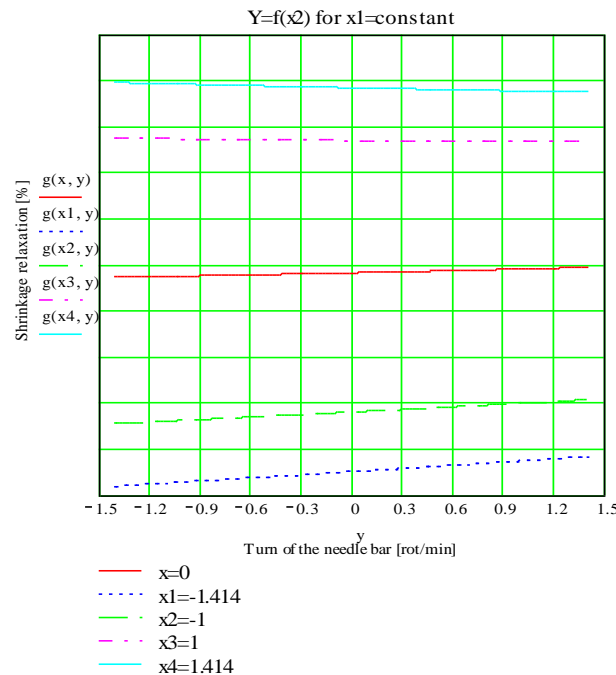


Figure 4. Variation $y=f(x_2)$ for x_1 in case of dimensional changes during relaxation, in the direction of vertical stitches courses, for jersey structures made of 100% cotton yarns, Nm 58/1.

From the graphic analyse from figure4, results the following:

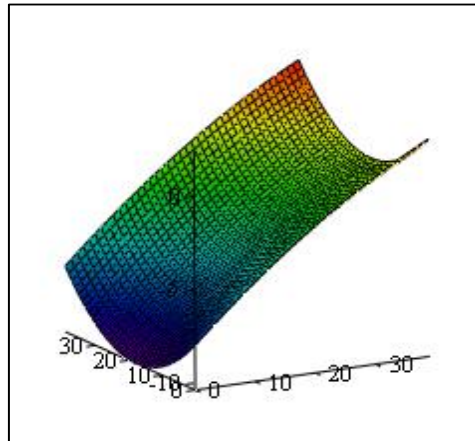
- The relaxation shrinkage on the stitch course direction for the jersey structures varies in lower limits together with the turn of the needle bar.
- The level curves have different evolutions.
- In the area of higher densities, the transition from one level to another is more difficult to be made, than in the area of lower densities.

Dimensional changes study on stitch course in vertical direction, during relaxation in raw condition, for the jersey structures, made of 100% cotton yarns, Nm 58/1.

The regression equation which describes the relaxation process in raw condition of the jersey structures made of 100% cotton, 58/1 metric count of yarn, on stitch course in vertical direction is given by the following relation (2):

$$f(x, y) := -5.86 + 2.511 \cdot x - 0.251 \cdot y - 0.191 \cdot x^2 + 0.774 \cdot y^2 \quad (2)$$

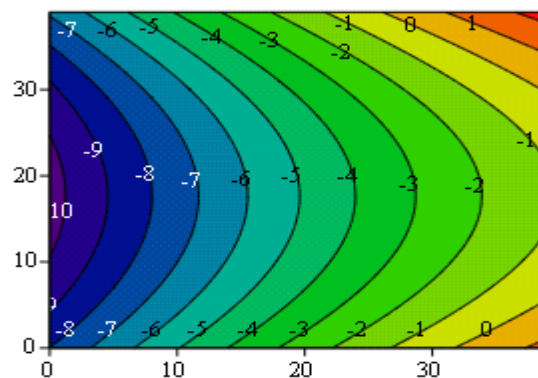
In figure 5 is represented the response surface, which means the dependence $y=f(x_1, x_2)$, in the shrinkage relaxation situation, on stitch course in vertical direction for the jersey fabrics which were studied.



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Figure 5. Response surface in the case of shrinkage relaxation, on stitch course in vertical direction, for jersey structures made of 100% cotton, Nm 58/1.

The response surface has a symmetric saddle shape. In figure 6 there are represented the level curves, respectively the sections through the response surface represented in figure 5, for different levels of y .



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Figure 6. Sections through response surface in shrinkage relaxation situation, on stitch course in vertical direction, for jersey structures, made of 100% cotton, 58/1 metric count of yarn.

From the graphic representation of the level curves which represent the sections through the response surface, results the following:

- The sections through the response surface are portions of ellipses.
- The relaxation shrinkage on the stitch course in vertical direction decreases together with the increase of the wale density.
- Once the turn of the needle bar increases, the relaxation shrinkage decreases until the real value of 19 rot/min, and after starts increasing.

In figure 7 is represented the dependence $y=f(x_1)$ for x_2 constant.

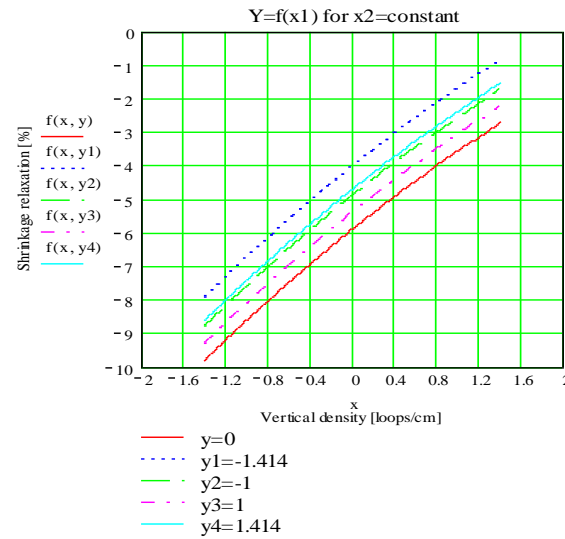


Figure 7. Variation $y=f(x_1)$ for x_2 constant in case of dimensional changes during relaxation, on stitch course in vertical direction, for the jersey structures, 100% cotton yarns, Nm 58/1.

From the graphic representation from figure 7 results the following:

- Together with the increase of the wale density, the relaxation shrinkage decreases.
- The level curves have the same evolution on entire variation range of the wale density.
- Both in the area of the higher densities and in the area of lower densities, the transition from one level to another is identical.

In figure 8 is represented the dependence $y=f(x_2)$ for $x_1=\text{constant}$.

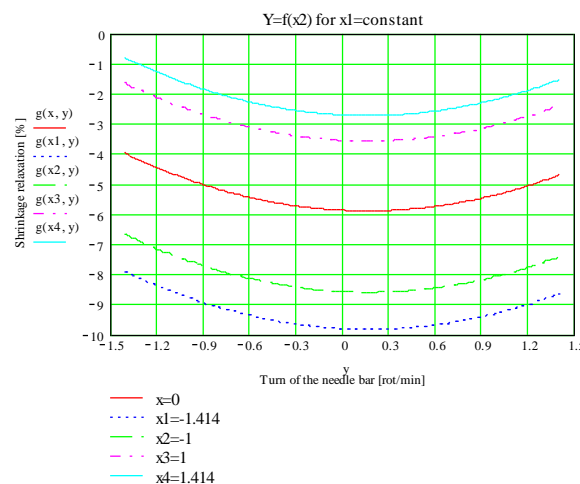


Figure 8. Variation $y=f(x_2)$ pentru x_1 in case of dimensional changes during relaxation on stitch course in vertical direction, for jersey structures made of 100% cotton, 58/1 metric count of yarn.

From the graphic analyze from figure 8 results that:

- The turn of the needle bar influences in a lower manner the shrinkage relaxation of the jersey structures.
- The level curves have the same evolution and presents a minimum.
- Shifting from one level to another is done with the same effort across the range of variation of the turn of the needle bar.

3. Conclusions

The wale density on the knitting machine is the fundamental parameter regarding the dimensional stability of the jersey structures studied;

All the operations and phases to which the yarns and knits are subjected will be driven with minimal and uniform tensions, avoiding fierce actions that can destabilize the structures;

Once the optimal wale density of the knitting machine has been established, the technological parameters of the knitting operations, the yarn feed rate, the turn of the needle bar, the knitting speed and the knitting pulling speed have considerably less influence on dimensional changes in the unfinished state of knitwear;

After relaxation of the knits after being removed from the knitting machine, it can be noticed that there are generally elongations in the stitch course direction and contractions in the stitch courses in vertical direction.

4. References

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