RESEARCH STUDY ON THE DIMENSIONAL STABILITY OF INTERLOCK 1:1 KNITTED FABRICS MADE OF COTTON YARNS

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Abstract: *The study concerns the dimensional changes resulted during the relaxation process after knitting, for tubular fabrics with interlock 1:1 structure, made of cotton yarn, with 50/1 metric count of yarn.*

For the study of the dimensional changes on both directions of the fabric, on the direction of stitches courses and on the direction of stitches courses in vertical direction, can be used a mathematical model with two variables.

The interlock 1:1 structures were obtained through the combined process of knitting, resulting a maximum uniformity of the structural parametres. The parameter's uniformity on entire kittng process is a determinant factor of the dimensional stability. The corelation between the yarn's characteristics, knitting machine's technical characteristics and technological parameters of the kntting process, leads to the achieving of knitted fabrics with minimum dimensional changes.

The interlock 1:1 stuctures which were analyzed in this study, were designed and produced so the final dimensional changes, after chemical finishing, this representing the last phase of the technological process from the knitting department, to be enclosed in the limits of ± 2%, both on the direction of stitches courses and on the direction of stitches courses in vertical direction.

Keywords: *knitted fabric, interlock 1:1 structure, dimensional stability, relaxation shrinkage.*

1. INTRODUCTION

The knitted fabrics are textile structures made of elastic interconnected stitches and characterized by two perpendicular directions, the direction of stitches courses on the direction of stitches courses in vertical direction.

The dimensional stability of the knitted fabrics is reflected in the capability of the products made from these, of maintaining the shape and dimensions in the predetermined limits, after several cicles of washing-wearing process.

The dimensional stability of the knitted fabrics made of cotton is a complex and widely studied issue worldwide. Due to the fact that these are elastic structures, the dimensional stabilization is obtained through the corelation of multiple paramenters, starting with the techological parameters of spinning operation of manufacturig the yarn, the knitting parameters, finishing parameters and finally by studying the washing-wearing behaviour of the clothing products made of these type of fabrics.

For this study,100% cotton yarns were chosen, with 50/1 metric count of yarn and with Z twist sense. Tubular knitted fabrics will be obtained. In this case, the tilt angles of the stitches courses in vertical direction, will become minimal for the tubular fabrics resulted.

The knitting process will be made with uniform alimentation supply for all yarns and on entire process, in order to avoid possible irregularities of the knitted stiches.

The knitted fabrics will be deposited in folded condition for relaxation, for 72 hours in a enclosure that complies with standard parameters (temperature=20^{0}C, relative humidity=60%, atmosperic pressure=760 mmHg). During this relaxation period, the stitches modify their shape without respecting a predetermined rule, and the final knitted fabrics balancing the internal tensions cumulated during knitting process. In knitting structures situation, the dimensional changes are influenced by the number of the yarn-yarn contat points of the structure’s elements, this fact leading to a superior dimensional stability compared to similar knitting structures, in wich the yarn-yarn contact point is smaller.

In table no.1 there are mentioned the technical characteristics of the knitting machines on which the structures were designed, the type and and metric count of the yarn which were used for knitting process and the structure of the fabric.

Table 1

Crt. No.	Knitting machine	Technical characteristics of the knitting machine				Yarn type	Metric count of yarn	Structure of the fabric
		Needle bar diameter [in]	Fineness [E]	Number of systems	Number of needles		[Nm]	
1	MULTIPIQUE TIP 5622-2	30	20	72	2x1872	100% cotton	50/1	interlock 1:1

2. MATERIALS AND METHODS

To determine the influence of techological parameters of knitting process on the dimensional stability, a mathematical model was established in order to define the connection between the relaxation shrinkage, which is considered a dependent variable, and as independent variables, the wale density and the turn of the needle bar.

The results of the practical determination were statistically processed. For the statistically process of the results, for all the knitting structures it was proposed an experimental program with 2 variables x_1 (x of ecuation) and x_2 (y of ecuation) which represent the entry data enclosed. x_{1real} represents the wale density on the knitting machine expressed in stitches/cm, and x_{2real} represents the turn of the needle bar expressed in rotations/minut. The values z_1 and z_2 are the answers.

For the study of the dimensional changes, made on the both directions of the knitted fabric, it is proposed a mathematical model as a rotatable central compound, with two variables. The coefficient's significance was tested with the T test and the adequacy with the Student test.

The experimental program concieved offers information regarding the behaviour of the knitted fabrics from entire variation domain of wale density and turn of the needle bar, proposed.

In table no.2 are represented the encoded and real values for the independent variables, and also the responses for the interlock 1:1 structure made of 100% cotton yarns, with metric count of yarn 50/1.

Table 2

Crt. No.	x_1 enclosed (x)	x_2 enclosed (y)	Wale density [stitches/cm] ($x_{1\ real}$)	Turn of needle bar [rot/min] ($x_{2\ real}$)	Dimensional changes during relaxation on stitch course direction [%] (z_1)	Dimensional changes during relaxation on stitch course in vertical direction [%] (z_2)
1	-1	-1	9,45	10,90	-2,00	-2,30
2	1	-1	11,60	10,90	-0,50	-1,50
3	-1	1	9,45	15,10	-2,50	-2,75
4	1	1	11,60	15,10	-0,75	-1,80
5	-1,414	0	9,00	13,00	-3,00	-3,20
6	1,414	0	12,00	13,00	-0,20	-0,40
7	-1	-1,414	10,50	10,00	-0,90	-1,40
8	1	1,414	10,50	16,00	-0,75	-1,30
9	0	0	10,50	13,00	-0,90	-1,20
10	0	0	10,50	13,00	-0,80	-1,40
11	0	0	10,50	13,00	-0,75	-1,50
12	0	0	10,50	13,00	-0,60	-1,30
13	0	0	10,50	13,00	-0,80	-1,25

Dimensional changes study on stitch course direction (horizontal direction):

The regression ecuation which describes the relaxation process of interlock 1:1 knitted fabrics made of 100% cotton, 50/1 metric count of yarn, stitch course direction is based on following relation (1):

$$f(x,y) := -0.77 + 0.901\cdot x - 0.471\cdot y - 0.067\cdot x^2 - 0.084\cdot y^2 + 0.062\cdot x\cdot y \quad (1)$$

Where: x and y are encoded values

In fig.1 is presented the dependence U=(f,y), in the case of relaxation shrinkage on the stich course direction of the interlock 1:1 fabrics studied.

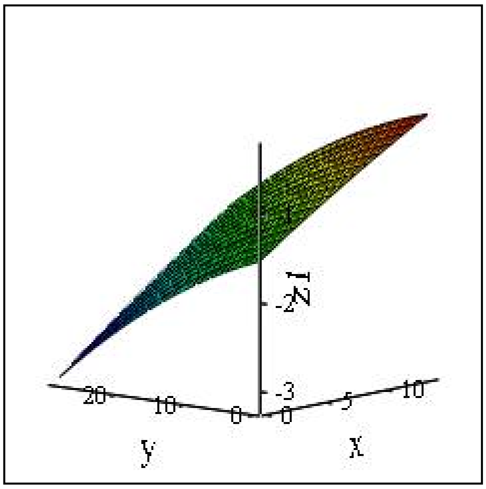

FIG. 1. Response surface in the relaxation shrinkage, on stitch course direction, for the interlock 1:1 knitted fabric

The response surface represented in fig.1 has an elongated saddle shape, and the curve which generates it are hyperbolas.

In fig. 2 there are presented sections through response surface, for the relaxation shrinkage on stitch course direction for interlock 1:1 knitted fabrics studied.

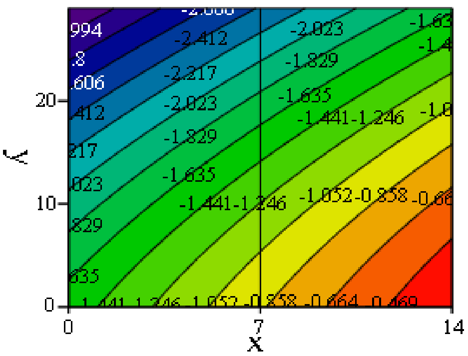

FIG. 2. Sections through response surface in the relaxation shrinkage, on stitch course direction, for the interlock 1:1 knitted fabric

From the graphic representation from fig.2, the level curves can be noticed; these are portions of hyperbolas.

While the wale density increases, the relaxation shrinkage decreases. For the entire field variation of wale density and of the turn of the needle bar, relaxation shrinkage appears (represented by negative values), but in elongation does not appear in any other situations (represented through positive values).

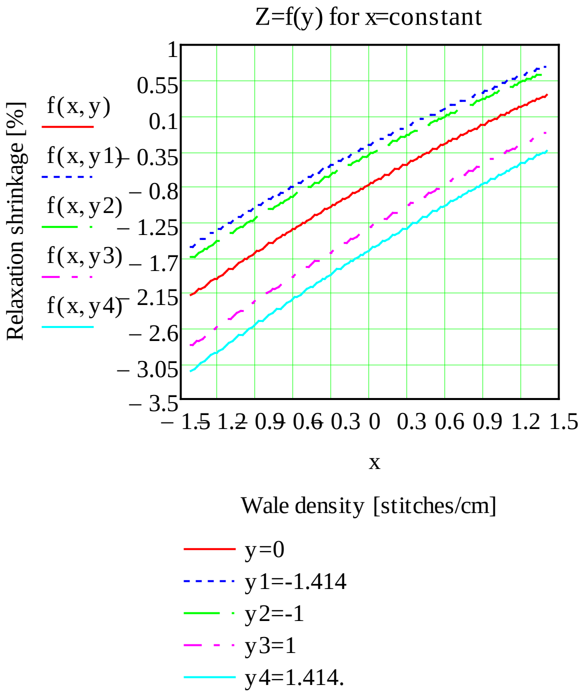

FIG. 3. Variation of Z = f(y) for x = constant in case of dimensional changes after relaxation, on stitch course direction in horizontal direction

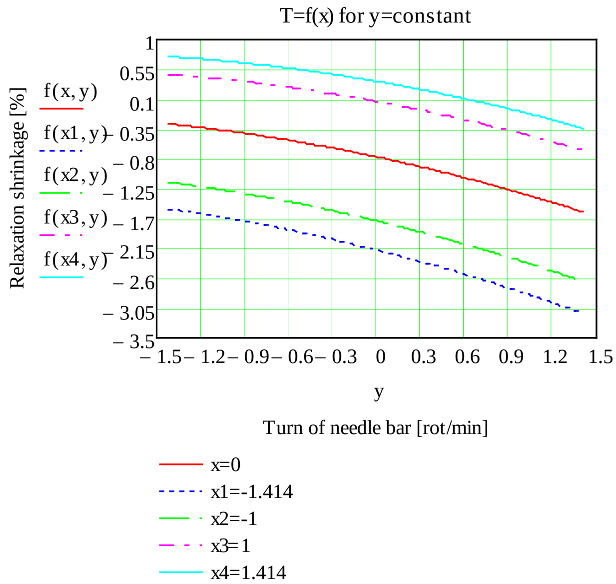

FIG. 4. Variation T=f(x) for y=constant in case of dimensional changes to relaxation, on stitch course direction in horizontal direction

In fig. 3 is represented the dependence of Z = f (y) for x = constant on stich course direction.

From the graphic analyze from fig.3 results that together with the increase of vertical density, the shrinkage to relaxation in the direction of vertical stitches courses decreases, approaching to the 0 value (ideal value). The curves present the same trend for the entire variation domain of vertical density. The switch from one level to another is done with the same effort for the entire variation domain of vertical density.

In fig. 4 is represented the dependence T=f(x) for y=constant.

From the graphic analyze from fig.4, it results that together with the increase of turn of the needle bar, shrinkage to relaxation increases in the direction of vertical stitches courses. The curves present the same trend for the entire variation domain of vertical density. The switch from one level to another is done with the same effort for the entire variation domain of vertical density.

Dimensional changes study on stitch course in vertical direction:

The regression ecuation which describes the relaxation process of the intrelock fabrics made of 100% cotton, 50/1 metric count of yarn, on stich course in vertical direction is given by the following relation (2):

$$f(x,y) := -1.33 + 0.714\cdot x - 0.363\cdot y - 0.076\cdot x^2 - 0.138\cdot y^2 + 0.037\cdot x\cdot y \quad (2)$$

In fig. 5 is presented the response surface, which means the dependence U=f(x,y), in the relaxation shrinkage on stitch course in vertical direction of interlock 1:1 fabrics which were studied.

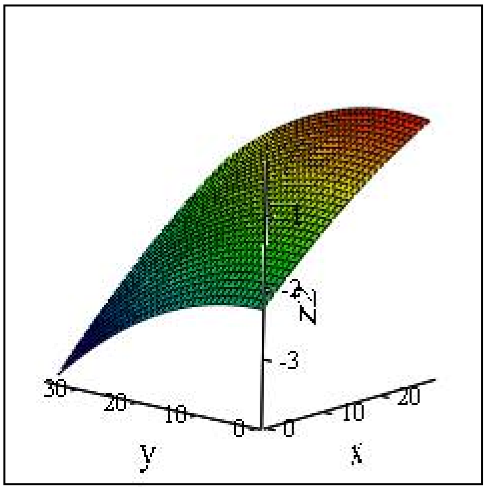

FIG. 5. Response surface in the case of relaxation shrinkage, on stitch course in vertical direction, for interlock 1:1 structures

The response surface has a elongated saddle shape. The curves which generates is are hyperbolas.

In fig. 6 are represented the sections through response surface, in the relaxation shrinkage case, on stitch course in vertical direction, for the interlock 1:1 fabrics studied.

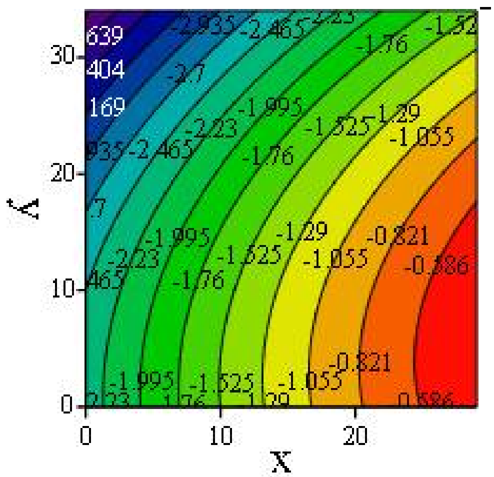

FIG. 6. Sections through response surface in relaxation shrinkage, on stitch course in vertical direction, for interlock 1:1 structures

From the graphic representation from fig.6, the level curves are evidenced, which are portions of hyperbolas.

Together with the increase of the wale density, the relaxation shrinkage decreases. For entire domain of variation of wale density and of turn of the needle bar, the relaxation shrinkage appears on the stitch course in vertical direction (represented by negative values), and in any case does not appear elongation (represented by positive values).

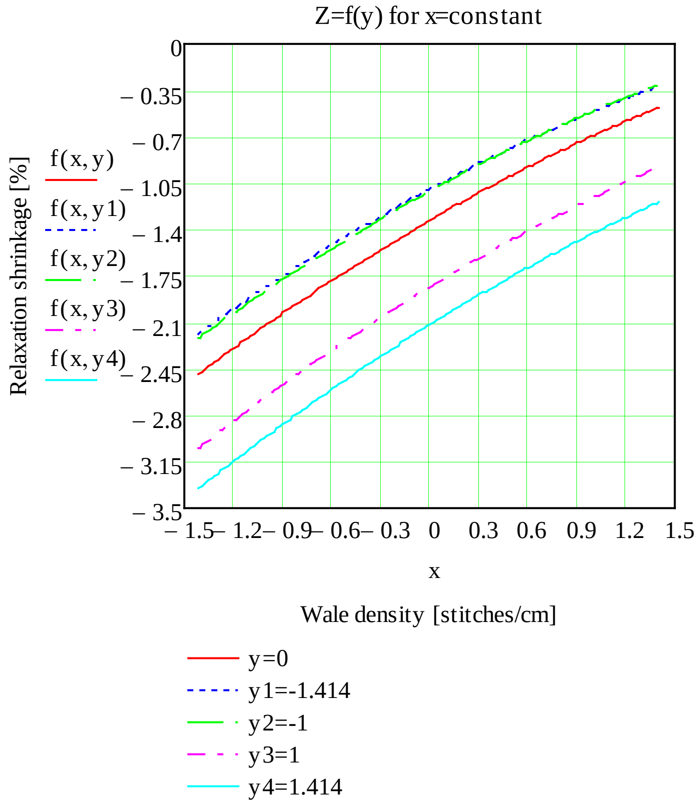

FIG.7. Variation Z=f(y) for x=constant in case of dimensional changes during relaxation, on stitch course in vertical direction

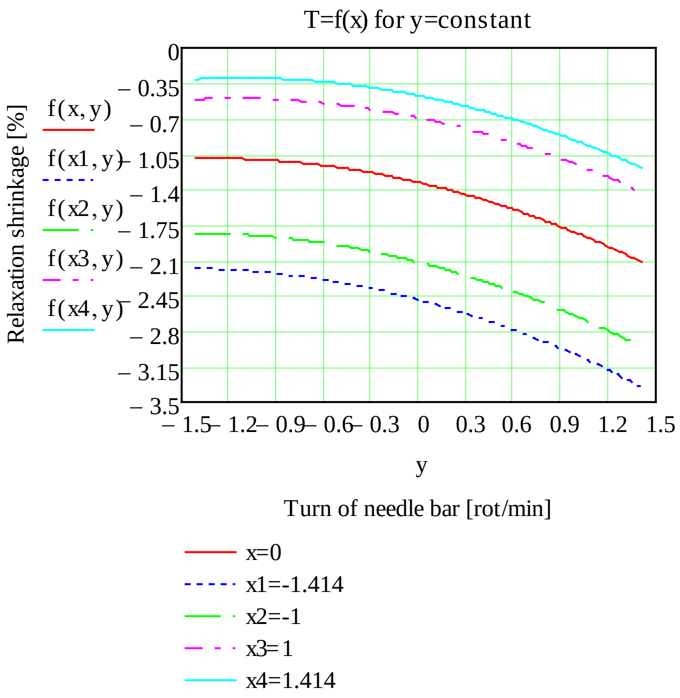

FIG. 8. Variation T=f(x) for y=constant in case of dimensional changes after relaxation on stitch course in vertical direction

In fig.7 is represented the dependence Z=f(y) for x=constant.

For the anlayze of graphic representation from fig.7 can be observed that together with the increase of the wale density, the relaxation shrinkage decreases on stitch course direction for the intrelock structures studied.

In fig. 8 is represented the dependence T=f(x) for y=constant.

From the graphic anlayze from fig. 8 results that together with the increase of the turn if the needle bar, the relaxation shrinkage increases. The curves have the same evolution for entire variation domain of wale density, the tranzit from one level to other is made with the same effort on entire variation domain of wale density.

3. RESULTS AND DISCUSSION

For real values of wale density between 10,5 -12 stitches/cm, the relaxation shrinkage decreases to -0,8% la -0,2%, which are considered very good.

Knitting with big wale densities, over 12 stitches/cm, elongations appear. These elongations appear due to increasing of yarn-yarn contact points, resulting yarn-yarn contact surfaces which lead to modifications of the stitches shape during relaxation period.

The variation of the wale density together with the turn of the needle bar in order to maintain a constant contraction is needed because once with the increase of the turn of needle bar over a certain value, the remanent tensions from the knitted fabric increase also, and in order to maintain the fabric in the same stich shape and at the same values of the structural parameters, the contact surface betewwn the yarns must be increased also.

A too high density does not allow the return through relaxation of the knitted fabric, to a minimum energy state and the remanent tensions manifest through contraction. Also, in the case of big wale densities, the knitted structures loose their elasticity and become.

4. CONCLUSIONS

1. The interlock 1:1 structures made of 100% cotton, 50/1 metric count of yarn studied, were designed so the dimensional chages during relaxation shrinkage to be minimum, this fact having a positive influence on previous procedures applied on knitted fabrics.
2. In order to obtain structures with dimensional stability in the limits of ±2%, the wale density of the knitted fabric determined on the knitting machine, has a major influence.
3. After establishing the optim wale density on the knitting machine, the turn of the needle bar must be set, the other technological parameters of the knitting process having less influence regarding the dimensional changes in un-finished state, of the knitted fabrics.
4. After the relaxation of the knitted fabrics which were released from the knitting machine, minimum contractions are noticed, both on the stitch course direction and on stitch course vertical direction, which concludes to a structure with very good dimensional stability.
5. The use of this method allows with a minimum effort, starting form initial data, which is the fineness of the yarns, technical characteristics of the knitting machine, the wale density, the turn of the needle bar, to predict the final data, more exactly the values of the dimensional changes after relaxation processes.

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