INFLUENCE OF FABRIC DIMENSIONS ON THE STRUCTURE AND DIMENSIONAL CHANGES IN RIB KNITTED FABRICS

By

V. HAVAS

Department of Textile Technology and Light Industry, Technical University, Budapest

(Received July 30, 1971)

Presented by Prof. Dr. A. VÉKÁSSY

1. Introduction

Due to the effect of the forces arising during processing, the dimensions of knitted fabrics at unloaded zero energy state considerably differ from the values measured during the knitting process [2]. Prediction of fabric dimensions is rendered difficult also by the fact that specific deformation after knitting is not independent of fabric dimensions in wale and course directions, respectively.

Fabric sheets produced on a flat knitting machine are subject to stretching in wale direction due to the operation of the take-up mechanism. As a result of the high contraction of the fabric structure, the force per wale exerted, increasing from the center towards the edges of the fabric, causing substantial variations in wale widths along the center line as compared to those at the edges of the knitted fabric sheets. As according to experience, differences show no proportionate variations along the fabric width, it follows that the full width of the fabric measurable during knitting is not either proportionate with the number of stitches contained in a stitch course, and thus with the number of needles to be found in the knitting zone.

As far as further processing and use of the fabric are concerned, fabric dimensions developed during knitting reveal no unambiguous trends yet, as further deformations taking place during deloading after the knitting process are superposed to the dimensional proportions of the fabric developed during knitting.

As a consequence of contraction, the cross-wise dimension of the fabric undergoes substantial changes along the fabric length. The fabric takes up then a form similar to that of a test fabric in a single-rip test, used for testing the mechanical properties of finished products (Fig. 1). In such measurements the clamping-in length of the fabric is prescribed by standard, consequently, the dimensional changes of the fabric are influenced not only by the number of wales but also by the number of courses. Changing the clamping-in length the extent of contractional distortion will vary over the whole fabric surface [4].

That may explain the experimental result showing a difference by 15 per cent in the full extension of a fabric when increasing the clamping-in length from 50 mm to 200 mm [3]. Since during knitting, and the subsequent relaxation, a process similar to that occurring in a single rip test takes place in the fabric, however, in opposite sense; it is probable that the distance between the place of fabric formation (the plane of the needle hooks) and also the other

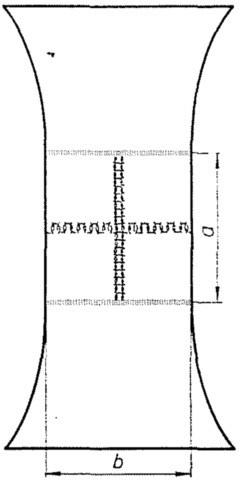

Fig. 1. Shape of a fabric sheet on a flat knitting machine, indicating the (*a*, *b*) measuring range

place where the fabric is clamped in (take-up mechanism) influence the dimensions of the knitted fabric. Since the location of the take-up mechanism on flat knitting machines differs for each type, testing the effect of this factor may prove fairly useful. Are the final dimensions of the fabric influenced to a considerable extent by the fabric length under stress, so the fabric structure itself will show variations, and thus, no identical fabric structures may be produced on different-type machines even for identical knitting parameters.

Deviations in wale dimensions (which may vary in dependence of the number of needles) can lead to variations in fabric structure over the surface of the fabric piece. Though, tests to produce homogeneous fabric structures [1] on available flat knitting machines are promising, the investigation into the relationship between initial fabric dimensions and fabric structure appears justified.

To study the phenomenon of contraction, two test series have been carried out. The influence of the number of active needles and that of the fabric length (the number of courses) clamped in, have been considered separately.

2. Experimental conditions

In order to increase the exactitude of measurements as much as possible, 100 courses each of the initial and final sections of fabric sheets (size *a* in Fig. 1) have been formed outside the fabric range to be measured, marking the boundary lines with inserting yarn ends of different colour.

Results have been determined as averages from three fabric pieces produced with identical setting parameters. In each test series, seven fabric groups of different initial dimensions have been knitted.

Main technological parameters of fabric formation

Type of yarn: worsted, Nm 28/2 nominal fineness, a blend of 70% wool and 30% viscose,
Type of package: cone
Winding machine: Varioconer; loading on the paraffin disc: 11.3 p
Knitting technology factors:

Yarn tension due to braking: 10.66 p
Take-up tension per stitch: 4.13 p*
Stitch cam setting: scale graduation: 9
Loop length: $l = 5.26$ mm
Treatment after knitting: relaxation on glass sheet.

3. Influence of the number of wales

In order to establish a relationship between the cross-wise dimension and the loop structure of the fabric, we have changed the number of needles in action within the range of 160 to 480 needles in almost equal steps. Fabric lengths between two measuring marks were always of 100 courses. Fig. 2 gives the values of loop width, while Fig. 3 those of loop height** for three characteristic fabric states: for the state in the knitting machine under loading; for that immediately after taken off the machine, thus the momentary elastic deformation after deloading; and for the state after 72 hours' relaxation. The dimensional change occurring between the first two states characterizes the momentary elastic deformation of the fabric, while the next state, the

* For achieving appropriate fabric take-up tension, the set-up comb has been weighted. As far as our experiment is concerned, the advantage of this method, as compared to roller-pair type mechanisms, lies in the fact that loops are subject to loading as long as knitting of the fabric piece is finished, thus, when on completion of the knitting process it will be taken-off from the machine the elastic deformation of the fabric can be determined. In order to ensure identical take-up tensions per stitch in each case tested, changes in the number of needles were corrected for by corresponding modification of the total loading.

** Loop height is understood as the part of the loop height parallel to wale direction, corresponding to the course height.

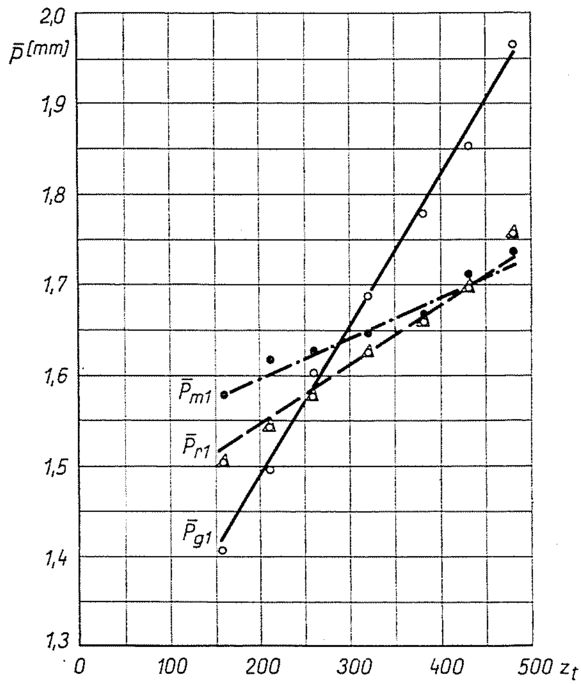

Fig. 2. Relationship between the number of needles (z_t), and the average loop width in a fabric under loading (P_g), immediately after deloading (P_r) and after relaxation (P_m), respectively

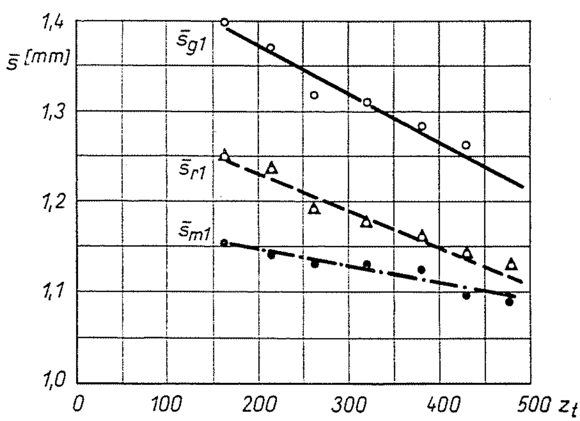

Fig. 3. Relationship between the number of needles and the average loop height in a fabric at the same states as in Fig. 2

range of the delayed deformation, refers to the visco-elastic properties of high-molecular polymers, valid also for textile materials. On the basis of the distribution of the average values with different machine settings, it appears convenient to use a linear regression for describing the probability relationship. The relationship of the calculated linear regression lines, and the correlation coefficients (r), expressing the extent of fitting, are as follows:

$$\bar{P}_{g1} = 1.67 \cdot 10^{-3} z_t + 1.150 \qquad r_{Pg1} = 0.987,$$
$$\bar{P}_{r1} = 6.59 \cdot 10^{-4} z_t + 1.414 \qquad r_{Pr1} = 0.845,$$
$$\bar{P}_{m1} = 4.53 \cdot 10^{-4} z_t + 1.506 \qquad r_{Pm1} = 0.981,$$

where:

$\bar{P}_{g1}$ — average value of loop width in the fabric on the flat knitting machine,
$\bar{P}_{r1}$ — average value of loop width after the momentary elastic deformation of fabric,
$\bar{P}_{m1}$ — average value of loop width at the permanent state of the fabric after relaxation, and
z_t — number of active needles.

The correlation coefficients show a very close fitting, thus the relationship between the number of needles and the loop width can be fairly well described by linear regression lines.

The values of loop height in dependence of the number of needles applied, are represented by the following linear regression lines (see Fig. 3):

$$\bar{S}_{g1} = -5.29 \cdot 10^{-4} z_t + 1.477 \qquad r_{Sg1} = 0.978$$
$$\bar{S}_{r1} = -4.08 \cdot 10^{-4} z_t + 1.312 \qquad r_{Sr1} = 0.985$$
$$\bar{S}_{m1} = -1.98 \cdot 10^{-4} z_t + 1.189 \qquad r_{Sm1} = 0.955$$

(with the same subscripts as in the calculation of loop width).

Also here, it appears that, as the fabric approaches its zero energy state, the absolute value of the direction tangent decreases towards zero.

In contrast to the case of loop width, the value of loop height will be lower with increasing number of needles. Thus, also from this trend it can be seen that an increase in the number of active needles will result in higher stresses in course direction of the fabric and this effect lasts even after relaxation.

4. Influence of the number of courses

Modifying the number of courses substantially less affects loop dimensions. For establishing the relationship between these two factors, tests were made with fabric lengths of 100 to 400 courses. Fabric length was modified

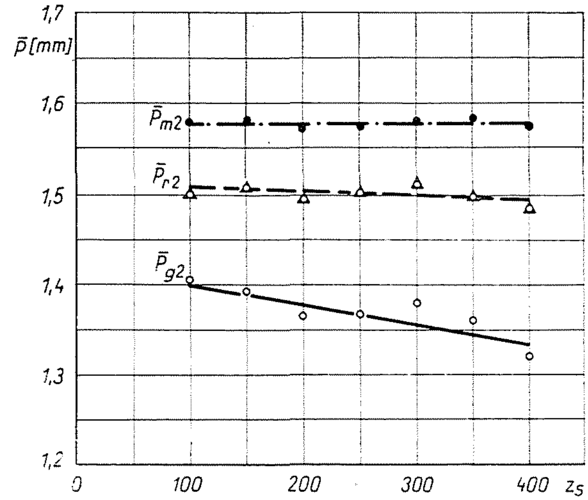

Fig. 4. Influence of the number of courses on the average loop width values

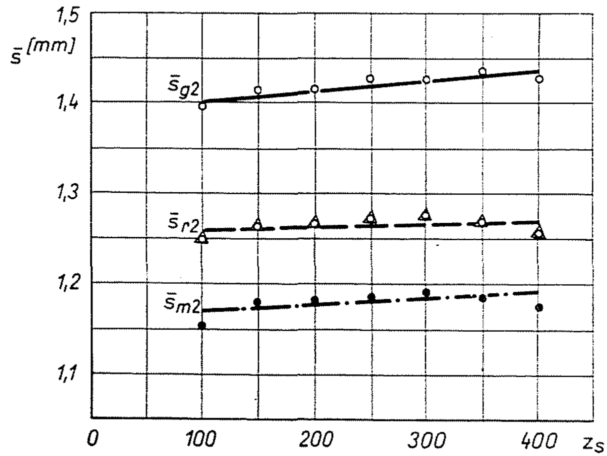

Fig. 5. Influence of the number of courses on the average loop height values

by 50-course increments. The average values obtained for loop width and loop height are given vs. the number of courses in Figs 4 and 5, respectively. Similarly to the method described above, the range of the measuring points has been approximated by straight lines, and using identical notations, the linear regression lines obtained are of the form:

$$\bar{P}_{g2} = -2.3 \cdot 10^{-4} z_s + 1.423 \qquad r_{Pg2} = 0.896$$
$$\bar{P}_{r2} = -4.9 \cdot 10^{-5} z_s + 1.510 \qquad r_{Pr2} = 0.648$$
$$\bar{P}_{m2} = 8.0 \cdot 10^{-6} z_s + 1.573 \qquad r_{Pm2} = 0.188$$
$$\bar{S}_{g2} = 1.09 \cdot 10^{-4} z_s + 1.394 \qquad r_{Sg2} = 0.920$$

$$\bar{S}_{r2} = 3.36 \cdot 10^{-5} z_s + 1.257 \qquad r_{Sr2} = 0.346$$
$$\bar{S}_{m2} = 5.93 \cdot 10^{-5} z_s + 1.165 \qquad r_{Sm2} = 0.526$$

where z_s is the number of courses between marks.

The equations give a value near to zero for the direction tangent of the straight lines, thus practically, loop dimensions are not influenced by the number of courses. Also the values of r_{Pr2}, r_{Pm2}, r_{Sr2} and r_{Sm2} show a loose relation between the number of courses and the dimensions of the loop.

5. Dimensional changes following the knitting process

In order to draw conclusions on the dimensional changes occurring in fabrics of given dimensions, fabrics specially produced for test purposes were compared also in this respect. The values of a and b in Fig. 1 were read

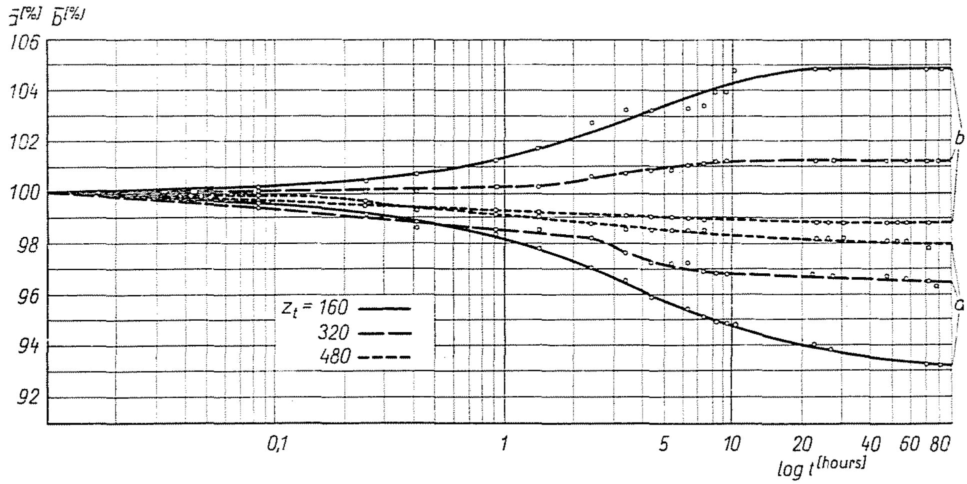

Fig. 6. Dimensional changes in wale and course directions, respectively, during relaxation, using different numbers of needles

off regularly, at an accuracy of $\pm$ 0.5 mm during the 72 hours' relaxation time. For dimensions of the order of 100 mm, this accuracy results in errors lower than $\pm$0.5 per cent. Considering the indefinite circumference line of knitted fabrics resulting from the very nature of knitting, no higher accuracy seems reasonable to be required.

Dimensions of a fabric deloaded after elastic deformation were applied as reference (100%), the further relaxation values are plotted vs. logarithm of time after deloading.

To avoid overcrowded figures, only the curves of the average dimensional changes of the fabrics z_t = 160, 320, and 480 (Fig. 6) produced by varying the number of needles, and z_s = 100, 200, 300 and 400 (Fig. 7) knitted by varying the number of courses, have been represented.

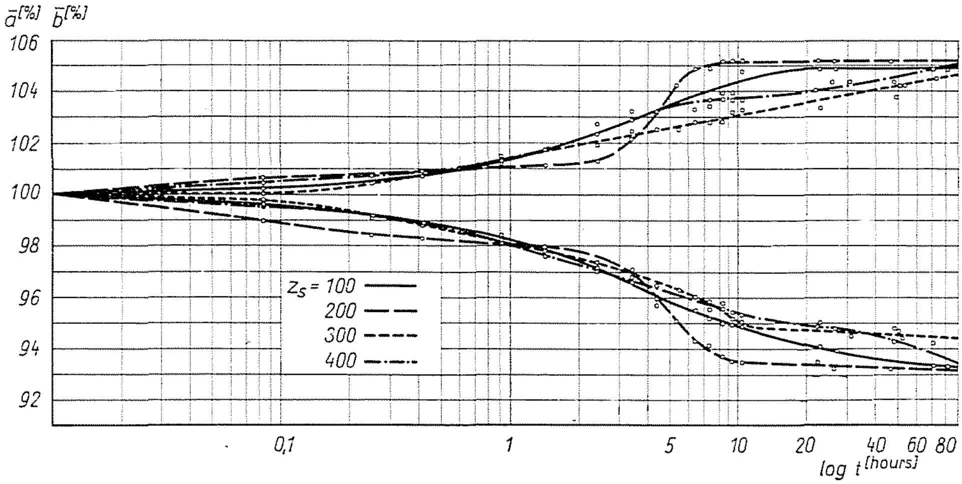

Fig. 7. Dimensional changes during relaxation in wale and course directions, respectively in fabric sheets, containing different numbers of courses

6. Evaluation of the experimental results

It is valid for all three states of the fabric that loop width increases in dependence of the number of needles. Thus, using n needles, the fabric width formed will be higher than n. Also mill experiments show a similar trend, as garment parts of different width knitted with identical settings (e.g. garment back and sleeves) show different wale density values, which is — as far as fabric quality, unit weight, and yarn consumption are concerned — fairly unfavourable. Thus, for achieving identical wale density values, machine setting parameters have to be modified, eventually by applying the relationships derived above.

From comparing the direction tangents of the straight lines $\bar{P} = f(z_t)$, it follows that upon increasing the number of needles, the highest increase in loop width will be observed in the fabric during loading, and this effect will be reduced by the relaxation process.

We have shown that upon increasing the number of needles, the stresses acting on the fabric in course direction increase. Namely, the clamping-in points of the fabric allow no shrinkage in course direction, and this, owing to the loop interlacings, causes considerable tension in course direction also in other sections further to the points mentioned. Taking simultaneous take-up tension into consideration, with increasing number of needles — due to the two perpendicular forces — an ever increasing, so called "surface elongation" can be observed. In that case the loop structure of rib fabrics approaches the arrangement shown in Fig. 8 and it will exhibit less deviation from the stitch arrangement of a relaxed fabric, than that of a fabric stretched only longitudinally. This is why, with increasing number of needles the curves of dimensional changes flatten, and — as it is seen in Fig. 6 — the interval of dimensional changes in percentage decreases. By increasing the number

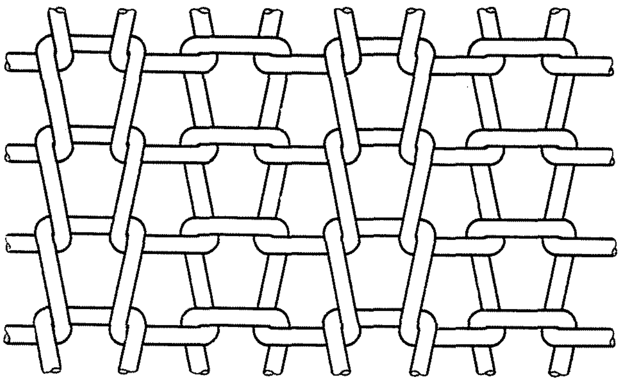

Fig. 8. Structure of rib knitted fabric stretched simultaneously in wale and course directions

of needles, in the fabric under loading on a flat knitting machine, the force acting in course direction may produce loop widths larger than those in a fabric at zero energy state. The number of needles corresponding to this extreme condition is given by the intersection points of the linear regression lines in Fig. 2. From the first intersection point ($z_t \approx 260$) to the second one ($z_t \approx 290$) related to the elastic deformation at deloading, the loop width in the fabric under loading decreases already, during the further relaxation process, however, it increases again, as a consequence of the loop rearrangement. At the subsequent interval, up to the next point of intersection ($z_t \approx 440$), the trends of the elastic and delayed deformations are similar to those described above, the values of loop width after relaxation are, however, lower than under loading. With more needles the loop width diminishes as soon as during relaxation. In this case (see the curve of the average dimensional change of fabrics produced with $z_t \approx 480$ needles in Fig. 6) there is a continuous decrease in b and thus, also in the fabric width, and shrinkage can be observed both in wale and course directions.

It follows from the above that the number of active needles influences not only the final dimensions of the fabric but also the character of the process of dimensional changes. This has to be taken into consideration when designing garment parts to be produced by different numbers of needles. From the dimensions of the fabric during loading in the machine, correct conclusion as to the final fabric dimensions can only be drawn on the basis of the trends shown in Figs 2 and 3.

In respect to changing the number of courses, practically, no influence on the dimensions of fabrics can be observed. This is also supported by the curves of dimensional changes in Fig. 7 showing a similar trend and approximately identical loop dimensions both in wale and course directions.

Summary

The relationship between initial dimensions (number of needles and courses) and those expected during knitting and after relaxation, in rib knitted fabric sheets produced on a flat knitting machine, has been studied. The experimental results permit to express mathematically the influence of initial, showing close correlations. The trends can be used for designing identical loop structures in knitted fabric sheets of different dimensions and they may also prove valuable in fabric design.

References

1. Bodó, L.: Magyar Textiltechnika **XIX**, 172 (1967).
2. Havas, V., Periodica Polytechnica M. E. **13**, 281 (1969).
3. Kobliakov, A. I., Technologia Legkoy Promishlennosti, **2**, 119 (1960).
4. Vékássy, A., Magyar Textiltechnika **XV**, 418 (1963).
5. Кобляков, А. И., Технология Легкой Промышленности 2, 119 (1960).

Dr. Vera Havas, Budapest XI., Sztoczek u. 2—4. Hungary.