NEW APPROACH TO A THEORETICAL STUDY OF SOME OF THE PARAMETERS IN THE KNITTING PROCESS, AND THEIR INFLUENCE ON KNIT-FABRIC STITCH DENSITY

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Abstract:

This paper proves relations, which concern the structure of knitted fabric by using a simple geometrical model. In addition, a series of graphics are made which allow fast, simple and effective analysis of the relations between some of the parameters of the knitting process and these of the ready-knit fabric. The quantity 'relative geometrical prolongation of the thread length in the stitch', introduced by me plays a significant role in this study. The relations given below allow the machine gauge to be defined; this helps to produce knit fabric with precisely calculated density by choosing appropriate values for the thread's sinking depth and acceptable average geometrical prolongation.

Key words:

prolongation, stitch, geometrical model, knitting.

The aim of this report is to theoretically analyse the interrelations between some of the parameters of the knitting processes, as well as finding appropriate values for them which can ensure the best quality of the ready products. With regard to this, the relation between the thread's sinking depth h in Figure1a and the achieved subsequent stitch density (courses or wales per 5 centimeters) of the knitted fabric which has been balanced and taken off the machine is important. The influence of the gauge of machine on this relation is also of interest. Apparently all these indexes contribute to the final dimensions of the ready-knit fabric.

The results obtained in this way could otherwise only be obtained by means of much experimental research, which is time-consuming and costs a great deal [1,2].

Our approach consists of choosing the appropriate geometrical model and theoretical definition of the relation between the parameters examined. The studies were mainly carried out on plain single stitch, but this approach can also be applied to other patterns.

The initial geometrical thread length, which participates in the loom formation ℓ_{kn} ($\ell_{knitting}$) [3], depends on the thread's sinking depth (h) as well as the geometrical dimensions of the loom formation elements. When the knit fabric is taken off the knitting machine and is completely balanced, the thread length in the stitch decreases ℓ_{sg} ($\ell_{shrinkage}$) (Figure1b). Apparently the decrease in ℓ_{sg} reflects the total areal shrinkage of the knitted fabric itself. On the other hand, during the knitting process the thread is tensioned, and it recovers after relaxation. Thus on one hand the length of the loom decreases geometrically, and on the other as a result of relaxation, there are no tensile forces.

In consequence of the theoretical analyses it is assumed that thread feeding is such that additional tension appears. Therefore it is assumed that there is only a geometrical difference between the two lengths ℓ_{kn} and ℓ_{sg}. This is important for the shrinkage of the knitwear after relaxation as well as for its behaviour when treated. The following is a theoretical analysis of the influence of various characteristics on this difference.

For easy definition, the change in the thread length is termed 'relative geometrical prolonging of the thread in the stitch', which is given by the following equation:

$$\varepsilon = (1 - \frac{\ell_{sg}}{\ell_{kn}})100\% \quad (1)$$

It is also assumed that the structure of the loom at the point when the loops are suspended on the needles corresponds to the simplified model given in Figure 1a. It is also assumed that the loop legs are vertical tangents to the sides of the needle (Figure 1, position 1), and the needle and connecting (sinker) loop respectively are horizontal tangents. All calculations are made on one level, as shown in Figure 1, without taking the thread thickness or the knitwear itself into consideration. This simplification of the loop geometry does not ensure precise results for the thread length in the loop (loop length). However, when comparing the different lengths measured with this model (e.g. ℓ_{kn} and ℓ_{sg} in formula 1) the mistakes are reduced to a minimum.

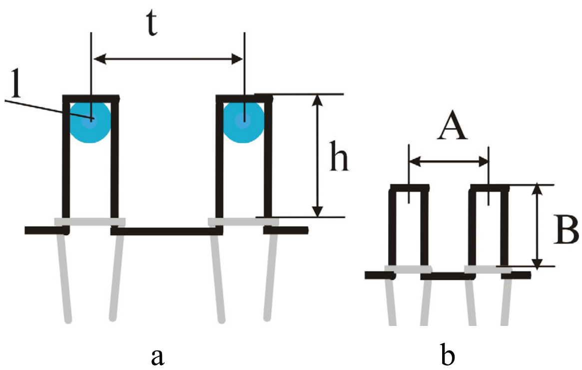

Figure 1.

The linear density of the yarn in the model used is not considered. Basically, in the relations as calculated, the pitch (needle space) t in mm (gauge of the machine E) is included, which to some extent reflects this feature, bearing in mind the relation between the machine gauge and the linear density of the thread used.

Table 1. Relative geometrical prolongation of the thread in stitch (ε) as a function of machine gauge (E), for different thread sinking depth (h), in mm, at P_c=20

Gauge (E)	Relative geometrical prolongation of the thread in stitch ε for different thread sinking depth h in mm, at P_c=20							
	2,8	2,9	3	3,1	3,2	3,3	3,4	3,5
4	33.9	35.06	36.11	37.13	38.11	39.07	40	40.89
6	19.73	21.33	22.87	24.35	25.77	27.14	28.46	29.74
8	10.03	12.04	13.96	15.79	17.55	19.24	20.86	22.41
10	3.07	5.39	7.61	9.72	11.74	13.67	15.52	17.29
12	0	0.25	2.71	5.05	7.28	9.41	11.44	13.39
14	0	0	0	1.49	3.89	6.18	8.36	10.44

Table 2. Relative geometrical prolongation of the thread in stitch (ε) as a function of machine gauge (E), for different coarse density (P_c), at h=3mm.

Gauge (E)	Relative geometrical prolongation of the thread in stitch ε for different coarse density (P_c), at h=3mm							
	14	16	18	20	22	24	26	28
4	8,73	20,14	29,01	36,11	41,92	46,76	50,85	54,36
6	0	3,59	14,3	22,87	29,88	35,72	40,67	44,9
8	0	0	4,39	13,95	21,78	28,29	33,81	38,54
10	0	0	0	7,61	16,01	23	28,93	34
12	0	0	0	2,71	11,55	18,92	25,16	30,5
14	0	0	0	1.49	3.89	6.18	8.36	10.44

Table 3. Relative geometrical prolongation of the thread in stitch (ε) as a function of sinking depth (h), for different coarse density (P_c), at machine gauge E=8.

Sinking depth (h)	Relative geometrical prolongation of the thread in stitch ε for different coarse density (P_c), at machine gauge E=8							
	14	16	18	20	22	24	26	28
2.6	0	0	0	5.73	14.3	21.44	27.48	32.66
2.8	0	0	0	10.03	18.21	25.02	30.79	35.73
3	0	0	4.39	13.95	21.78	28.29	33.81	38.54
3.2	0	0	8.39	17.55	25.04	31.29	36.58	41.11
3.4	0	1.07	12.06	20.86	28.05	34.05	39.12	43.47
3.6	0	4.89	15.46	23.91	30.83	36.59	41.47	45.65

It follows from Figures 1a and 1b that

$$\ell_{kn} = 2h + t \qquad (2)$$

and

$$\ell_{sg} = 2B + A \qquad (3)$$

It is known [4] that when we have single plain knitting, which is the object of our research

$$\frac{B}{A} = 0{,}865 \qquad (4)$$

Replacing (4) in (3) we have

$$\ell_{sg} = 3{,}15B \qquad (5)$$

Replacing (3) and (5) in (1), and regarding the fact that course density (course per 5 cm) $P_c = \frac{50}{B}$ have

$$\varepsilon = (1 - \frac{15{,}78}{P_C(2h+t)})100\% \qquad (6)$$

It follows from $t = \frac{25{,}4}{E}$ that

$$\varepsilon = (1 - \frac{15{,}78E}{P_C(2Eh+2{,}54)})100\% \qquad (7).$$

Formulas (6) and (7) give the geometrical prolonging of the thread length in the stitch in respect to the thread's sinking depth (h), the pitch (t), the machine gauge (E) and the course density of the ready knitwear. A detailed analysis of these formulas could give interesting results for the technological features of the knitting process and the basic qualities of the ready knitwear, which have practical significance even though they have only theoretically been proved.

The formulas (6) and (7) are used to search analytically for the influence of the various features over the 'relative geometrical prolongation of the thread length in the stitch', and respectively the shrinkage of the knitted fabric when taken off the knitting machine. In Tables 1, 2 and 3, the value of ε and the different values of knitted fabric parameters are given. Table 1 shows ε at a constant course density of the knit fabric and different values of the thread's sinking depth. Figure 1 clearly shows that when the values of h are higher, ε is higher too. If the machine gauge is smaller, the influence of the depth of folding over the relative prolongation is less. With fine gauge machines the relative geometrical prolongation ε is smaller. The theoretical results, where ε is equal to 0, show that the respective values of the indices could not be real, and the knitwear could not actually be produced.

Figure 2 gives the opportunity to define the machine gauges when, by choosing the appropriate values of the thread's sinking depth and the average acceptable geometrical prolongation, knitwear with course density of 20 stitches per 5 cm could be produced. For example, to produce knitwear with density of 20 stitches per 5 cm, a knitting machine with 7E at h=3.4 mm and a relative geometrical prolongation of about 24% should be used. When decreasing the value of h at the same machine gauge, the relative geometrical prolongation is decreased too. A series of graphics similar to Graphic 1 could be drawn and used according to the afore mentioned method.

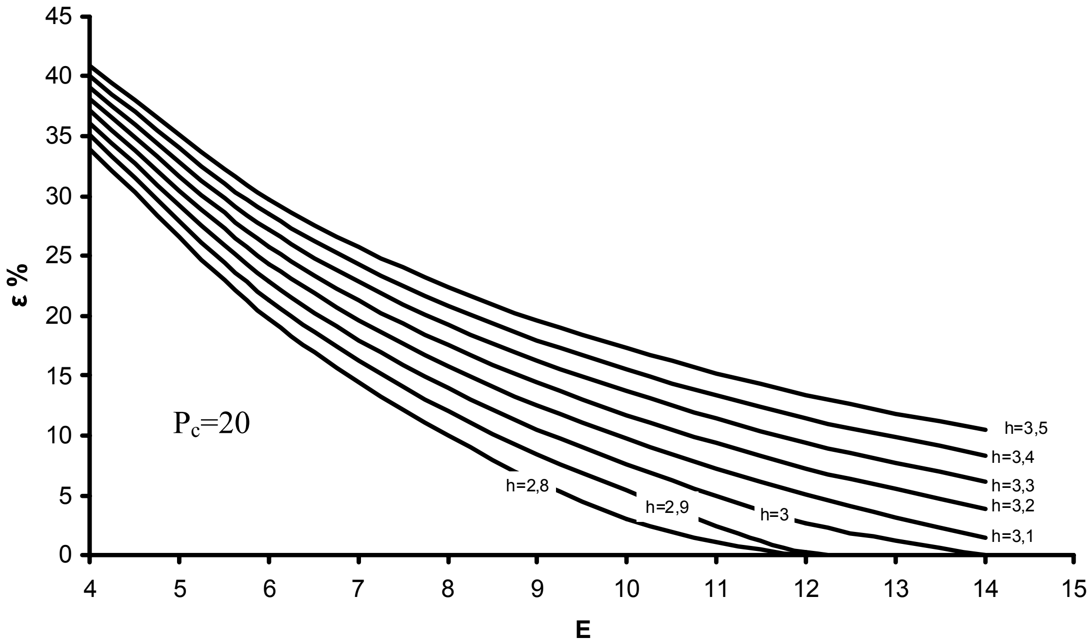

Figure 2. Relative geometrical prolongation of the thread in stitch (ε) as a function of machine gauge (E), for different thread sinking depth (h), in mm, at P_c=20

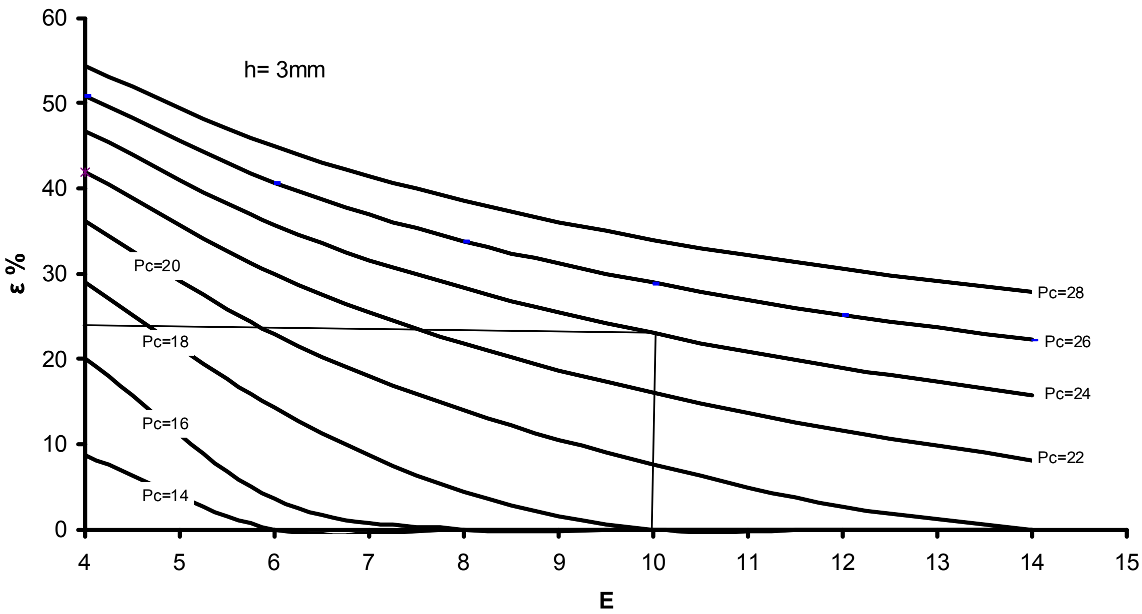

Figure 3. Relative geometrical prolongation of the thread in stitch (ε) as a function of machine gauge (E), for different coarse density (P_c), at h=3mm.

Figure 3 gives the relations between the machine gauge, knitwear course density and the relative geometrical prolongation of the thread in the stitch at a thread's constant sinking depth. For example, the value of ε about 23% with a machine with gauge 10E and h = 3 mm, a knitwear with P_c = 24 courses per 5 cm could be produced. The theoretical results, where ε is equal to 0, show that the respective values of the indices could not be real and the knitwear could not actually be produced. A series of graphics similar to this one could be drawn when having different h values.

Figure 4 is examined in the same way as the other two graphics. For a machine with gauge 10E, definite ε and the necessary density, the thread's sinking depth is determined. For example, ε =20 % and P_c=22 courses per 5 cm, the thread's sinking depth should be 2.89 mm.

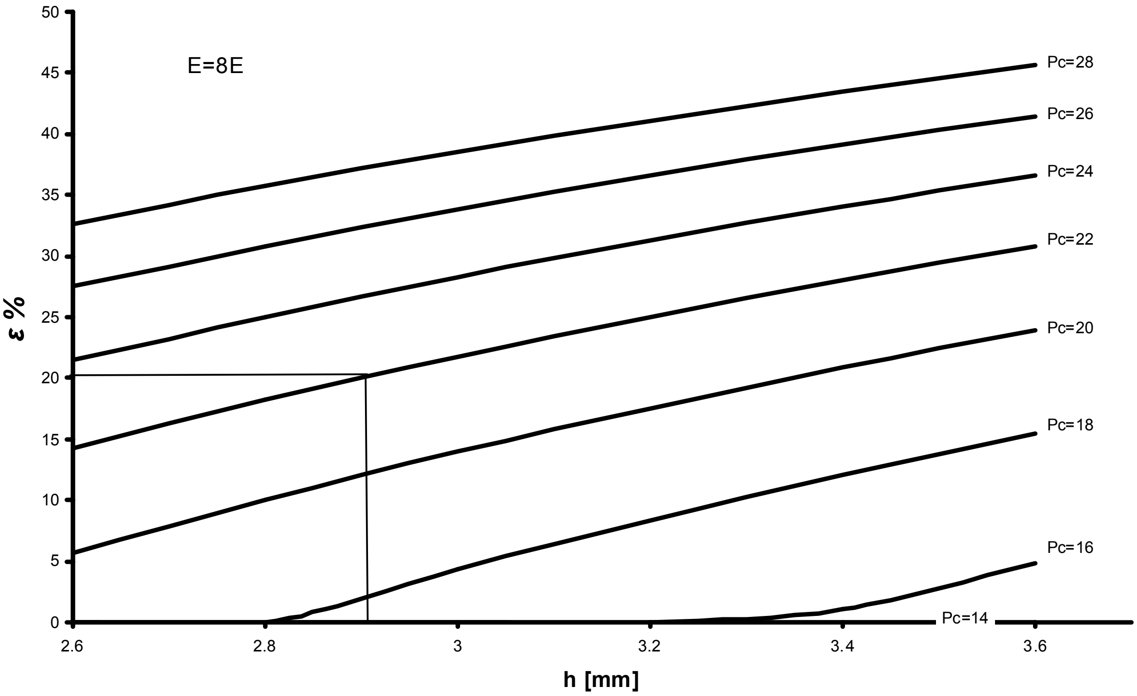

Figure 4. Relative geometrical prolongation of the thread in stitch (ε) as a function of sinking depth (h), for different coarse density (P_c), at machine gauge E=8.

The fact that the value of ε determines the stability of the produced knitwear, its shrinkage and treatment should be taken into consideration. The ε values must be carefully chosen when using the graphics.

Conclusion

The conclusion which could be drawn is that the approach offered can easily analyse the existing relations between the different parameters in the knitting process and the parameters of the ready knit fabric.

References:

1. *Mutic, S.R. Dimensional stability, aesthetic and mechanical properties of micro-fiber blended knitted fabrics, National Textile Center Annual Report: September 30, 1993*
2. *Anand S.C., K.S.M. Brown, L.G. Higgins, P.A. Holmes, M.E. Hall and D. Conrad, Effect of laundering on the dimensional stability and distortion of knitted fabrics, Autex research Journal, vol. 2, № 2, June 2002.*
3. *Гарбарук В. Н. Проектирование трикотажных машин, Ленинград, 1980 (in Russian).*
4. *Далидович А. С. Основы теории вязания, Москва, 1970 (in Russian).*

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