COMPARATIVE STUDY REGARDING THE EXTENSIBILITY OF WEFT KNITTED FABRICS BY

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Rezumat

Extensibilitatea reprezintă un indicator al comportării materialelor tricotate pe durata procesării lor ulterioare i apoi pe durata utilizării. Extensibilitatea tricoturilor depinde în principal de caracterisiticile materiei prime i de structura acestora. Geometria dispunerii firelor în ochiurilor de tricot i lungimea de fir din ochi au o influen ă puternică asupra extensibilită ii.

Lucrarea studiază extensibilitatea tricoturilor din bătătură pe direc ia rândurilor i a irurilor de ochiuri. Pentru a elimina influen a materiei prime, mostrele de tricot au fost tricotate din acela i fir. S-au folosit legătura glat i patent, fiecare structură fiind realizată cu mai multe trepte de desime. Mostrele au fost relaxate i finisate după care au fost testate pentru determinarea extensibilită ii folosind diferite valori ale for ei, considerate în intervalulnormal de solicitare, conform standardelor.

Datele experimentale au fost prelucrate i comparate, astfel încât să se poată pune în eviden ă influen a structurii i a parametrilor de structură asupra extensibiltă ii tricoturilor

Abstract

Extensibility is an indicator of fabric behaviour during subsequent processing and use. The fabric extensibility depends mainly on the yarn characteristics and on the fabric structure. The yarn geometry within the fabric and the stitch length strongly influence its extensibility.

The paper studies the extensibility on both directions of weft knitted fabrics. The samples are knitted with the same yarn so that the yarn influence is neglected. The fabrics are produced with different basic evolutions – jersey and rib, with different stitch density. The samples were relaxed and finished and then tested for extensibility at different force values, considered to be in the range of normal strains, according to standards.

The experimental data were processed and compared so that the influence of knitted structure and structural parameters is emphasised.

1. Introduction

The mechanic behaviour of the knitted fabric is of most importance, during processing as well as use. The strain reaches the rupture point almost never, in most of the cases the force level corresponding to the elastic domain.

Due to their specific geometry, the weft knitted fabrics are characterized by high elasticity, especially on row direction. Low forces will generate high strains. This behaviour recommends such structures for products where elasticity and/or formability are required.

Fabric extensibility represents the fabric capacity to reach the maximum value of elongation under forces below breaking point. During handling, the fabrics elongate so it is important to understand this process, especially in the case of weft knitted structures.

The paper presents a study regarding the extensibility of knitted fabrics. Three common types of knitted structures were chosen – jersey, 1x1 rib and 2x2 rib. These fabrics are widely used in practice for different parts of a garment, but they can also be used for technical applications. The samples were produced using five different stitch densities, in order to determine the influence of structural parameters on extensibility.

The fabrics were tested using a Frima Fabric Extensiometer, SDL Atlas, using two force levels. First a 3000 g weight (30 N) was used, as stated in the machine manual. The second weight is 600 g (6N), considered to be a value closer to the ones occurring during use.

The experimental data are then compared in order to define the extensibility mechanism and the influence factors.

2. Experimental Work

The fabrics to be tested for extensibility were produced on a flat knitting machine, using a blend yarn (67 % cotton and 33% acrylic). The evolutions chosen are: jersey, 1x1 rib and 2x2 rib.

2.1. Raw Material

The yarn used to knit the samples is 67% cotton and 37% acrylic blend, nominal count 2x36 tex. The yarn was tested to determine its count, friction coefficient (1, 2) and torsion parameters. The tensile behavior (3, 5) was also studied, determining the stress–strain curves on a Mesdan testing machine. Table I presents the yarn characteristics and Figure 1 a stress- strain curve.

Table I. Mean values for yarn parameters								
Yarn count	Torsion		Friction coefficient					
T _{tex}	T(rev/m)	$\alpha_{ m M}$	Yarn-yarn	Yarn - ceramics				
72.73	365.37	98.2	0.47	0.66				



Figure 1. Stress –strain curve for the yarn

The yarn is characterized by a rough touch, caused mainly by the cotton fibres. It also presents a certain rigidity that did not affect the knitting process. The yarn is uniform. The cotton fibres also increase the friction coefficient. The value for yarn on yarn friction is important because it will influence the yarn redistribution within the strained stitch.

2.2. Knitted Fabrics

The fabrics were knitted using a CMS 330 TC Stoll machine, gauge 7 E. The five values selected for the quality stitch cam are based on practical experience and are intended to cover the normal range for fabric stitch density. The same yarn tension and take-down force were used for all samples. The fabrics were produced on all needles, with the same number of rows. Figure 2 presents the three evolutions.





2x2 rib evolution

Figure 2. Representation of knitted fabrics

After knitting, the fabrics were relaxed in dry state and then finished. The structural parameters determined according to standard (4) are presented in Table II. The horizontal stitch density values for the rib fabrics are considered for one side of the fabric, so they must be doubled when considering the total number of stitches. The highest values for the fabric weight are presented by the 2x2 rib fabric, indicating that this structure has the highest number of stitches on the surface unit. The 1x1 rib fabrics have the highest stitch length due to the presence of only rib stitches, while the 2x2 rib fabrics have rib and jersey stitches. The jersey fabrics have the highest stitch density, but the stitches are positioned in a singular plan.

			Table II. Budetalai parameters of kintied fat		
		Horizontal stitch density [stitch/10 cm]	Vertical stitch density [stitch/10 cm]	Stitch length [mm]	Fabric weight [g/m ²]
Jersey	10.5	48	92	6.43	520
	11.0	46	80	6.91	480
	11.4	44	72	7.53	440
	11.8	44	62	8.14	425
	12.2	44	56	8.38	400
1x1 rib	10.5	35	58	8.51	650
	11.0	33	55	8.82	600
	11.4	33	52	9.24	555
	11.8	32	46	9.76	530
	12.2	32	44	10.48	515
2x2 rib	10.5	37	68	7.53	820
	11.0	36	65	8.09	760
	11.4	36	58	8.69	720
	11.8	34	54	9.21	670
	12.2	34	50	9.43	620

Table II. Structural parameters of knitted fabrics

2.3. Fabric Testing

The extensibility of the knitted fabrics was determined using a Frima Fabric Extensiometer, SDL Atlas (see Figure 3). The samples were cut on row and wale direction, according to standard (5). The apparatus measures directly the knitted fabric extensibility on a scale up to 300%. As mentioned above, the fabrics were tested with two weights: 3000 g and 600 g. Each variant had five samples tested on the row and wale direction.



Figure 3. Frima Fabric Extensiometer

3. Results and Discussions

The experimental data obtained for extensibility on row and wale direction is presented in Tables III and IV, for all five positions of the stitch quality cam. These values allow not only for a ranking of the fabrics, which to a certain point is predictable, but also for comparisons between the extensibility determined for these structures and the selected structural parameters. Another point to emphasize is the way the samples behaved after testing, precisely how the samples looked immediately after testing and the way the fabrics recovered in time.

	NP	10.5	11.0	11.4	11.8	12.2		
3000 cN	Jersey	34	48	69	97	102		
	1x1 rib	219	254	265	290	Over 300		
	2x2 rib	210	255	280	Over 300	Over 300		
600 cN	Jersey	16	25	42	53	59		
	1x1 rib	155	165	180	202	224		
	2x2 rib	135	146	178	215	240		
Table IV. Mean values for extensibility – wale direction								
NP		10.5	11.0	11.4	11.8	12.2		
3000 cN	Jersey	47	48	51	57	62		
	1x1 rib	62	65	66	67	70		
	2x2 rib	61	62	63	65	68		
600 cN	Jersey	18	22	24	30	36		
	1x1 rib	27	32	37	40	41		
	2x2 rib	28	31	35	37	45		

Table III. Mean values for extensibility – row direction

3.1. Extensibility Mechanism

The following three distinct stages were identified to occur during the extensibility tests:

- 1. The front and rear stitches are levelled and brought in the same plan. This initial stage requires a very low force and is specific to the rib fabrics. In the case of the jersey fabric this stage is missing due to the specific geometry. The elongation depends on the number of structural elements in the volume unit that will be discussed later. The elongation along the wale direction does not include this stage.
- 2. The yarn is redistributed, mostly along the row direction, decreasing the stitch height and increasing the stitch pitch. When straining the fabrics on the wale direction, this redistribution is much smaller and is based mainly on the length of the sinker loops.
- 3. The fabric elongates due to the specific elongation of the yarn. Depending on the force applied, the yarn elongation can remain in the elastic domain, or can reach the plastic deformations. The value of this stage depends directly on the characteristics of the yarn used to produce the samples.

3.2. The Influence of the Tensile Force

From Tables III and IV it is clear that the force applied during testing has an important influence on the fabric extensibility. Still, it must be pointed out that even if the second force value is 5 times lower than the initial standardized value, the decrease in extensibility is lower than 50 %. The most affected by the change in testing weight are the jersey fabrics, where the differences are between 42% and 53%, while the less affected is the 1x1 rib, where the differences are also in a smaller interval (29 - 35%). Figure 4 exemplifies the variation of row extensibility with the testing force in the case of the 1x1 rib fabrics. The difference between extensibility determined for 3000 cN and 600 cN increases with the stitch density (decrease of the stitch quality cam position).



Figure 4. The influence of the testing force on the fabric extensibility

An interesting aspect is the way the fabrics recover after the tensile strain. In the case of the 3000 cN tests, the 1x1 rib fabrics presented a remnant strain after the samples were removed and relaxed, showing that the fabric went over the elastic domain. The 2x2 rib fabrics recovered easily from the strain. The situation disappears when testing with 600 cN, both types of fabrics recovering immediately. This indicates that 3000 cN is too high for the 1x1 rib fabric. One possible conclusion is that a single value for the testing force, as presented by the standard, is not enough and should be determined according to the structure, yarn and destination.

3.3. The Influence of the Fabric Structure

The experimental values rank the fabric row extensibility depending on the type of evolution as expected: the lowest values are presented by the jersey fabrics; the 1x1 rib fabrics present the medium extensibility, while the 2x2 rib fabrics have the highest ones. The row extensibility of the 1x1 rib fabrics is very close to the one determined for 2x2 rib fabrics.

The explanation for this ranking comes from the number of stitches in the surface (volume) unit. More structural elements in the surface unit mean a larger redistribution of the yarn. The specific geometry of the each type of structure, presented in Figure 5 in an upper view of the stitch cross section, show that the 2x2 rib fabrics have the highest number of structural elements, therefore its extensibility is the highest. The relative position of the front and rear stitches, illustrated in Figure 5.c, also depends on the structural parameters. A lower stitch length generates a higher tension in the stitches and this decreases the angle made by the stitches with the same aspect.







a) jersey b) 1x1 rib c) Figure 5. Position of the structural elements for the three evolutions (upper view of the stitch cross section)

In the case of row extensibility, the jersey fabrics present much lower values than the rib fabrics, as illustrated in Figure 6.a. The extensibility on the wale direction is significantly lower than the one determined for the row direction. The values are placed in a small interval, regardless of the type of the structure, for both strain values (see Figure 6.b). Such differences are caused by the way the yarn redistributes itself when strained. In the case of row elongation, the yarn migration takes place mostly from the stitch arms, while in the case of wale elongation, as mentioned when presenting the extensibility mechanism the yarn migration comes from the sinker loops.



Figure 6: The influence of fabric structure on extensibility

3.4. The Influence of the Structural Parameters

Among structural parameters, the stitch density (adjusted on the machine using the stitch quality cam) has the most significant influence. A higher density determines a decrease in fabric extensibility, due to the lower stitch length that restricts the yarn redistribution. This relationship was observed for all types of fabrics, both testing directions, as well as both testing forces.



Fig. 7: The influence of the stitch density (quality cam position) on fabric extensibility

On the wale direction, the relationship between extensibility and the stitch density is the same, but the variation interval is smaller, showing that the influence of the structural parameters on wale extensibility is reduced.

4. Conclusions

The extensibility of weft knitted fabrics gives a strong indication regarding their behaviour during processing and use. The weft knitted fabrics are elastic and therefore it is important to define the fabric capacity to elongate under low forces.

The extensibility was studied on three types of knitted fabrics – jersey, 1x1 rib and 2x2 rib. The samples were knitted with different stitch density (through the adjustment of the stitch quality cam). The extensibility was tested on row and wale directions, using two different forces – 3000 cN (30 N) indicated by the machine manual and 600 cN (6N) considered to be a value common in practice. The following conclusions can be drawn:

• The extensibility of knitted fabrics presents three stages when considered along the row direction and two stages for the wale direction

- The extensibility is higher on the row direction, mainly due to the possibility to redistribute a higher length of yarn than on wale direction.
- The extensibility varies with the testing force, the differences not being proportional to the difference between forces. This indicates that there is a limit regarding the elongation in the elastic domain.
- The fabric structure influences mostly the row extensibility, through the number of structural elements (stitches) in the volume unit.
- The structural parameters influence significantly the row extensibility, due to the fact that the stitch length (and implicitly stitch density) allows for a higher or smaller amount of yarn to be redistributed during fabric elongation. The influence on wale extensibility is not so strong.

Acknowledgements

The present paper is published under the research project ID_589, no. 376/2007, funded by the Romanian Government.

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