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Influence of miss knit repeat on parameters and properties of elasticized knitted fabric

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Abstract. The features of elasticized knitted fabric are: high extensibility, elasticity and adaptability to a body shape and a compression effect when it is used in the extended state. The elasticity of a knitted fabric is enhanced by the incorporation of elastane thread or core-spun yarn into the knitted structure as the weft yarn that is laid in the stretching direction. The quality of elasticized knitted fabrics is determined by the reliability of the how the elastomeric yarn is fixed within as the structure is deformed with an increase in the contact areas between the elastomeric and conventional yarns. The high fixing level can be achieved by the nature of loops formed from the elastomeric yarn. The simultaneous union of both conditions is possible with miss-knitting of elastomeric yarn through a certain number of needles. The main purpose of this study is to establish the influence of miss knit repeat of elastomeric yarn on the structural parameters and determine the stretch properties of the elasticized knitted fabric that formed by an alternation of two courses of 1x1 rib from cotton yarn and one course of miss knit (from 2 to 10 wales between the loops) from core-spun yarn with elastane core.

1. Introduction

Application of textiles in medicine and health care can prevent and delay disease progression. The knitted fabrics with incorporated elastane is one of textile materials which use has increased in recent decades. The features of such materials include high extensibility, elasticity and adaptability to a body shape that is indispensable in compression garment [1]. In addition, elasticized knitted fabric creates a compression effect when it is used in the extended state [2]. That is why the elasticized knitted fabrics are indispensable in the manufacturing of therapeutic and prophylactic products, such as elastic bandages. bands for different purposes and abdominal binders [3]. The quality, functional and hygienic properties of materials are very important for the manufacture of medical items for rehab assignment. The hygienic requirements are ensured by using knitted fabrics from natural yarn. The physical and mechanical properties are achieved through the use of elastomeric yarn.

The elasticity of a knitted fabric is provided by the incorporation of elastane thread or core-spun yarn with elastane core into the knitted structure as the filling yarn that is laying in the stretching direction [4]. For example, when the elastomeric yarns are used as weft-inserted thread into the weft

knit, the fabrics has got an extensibility in coursewise direction. At the same time, an elastomeric yarn should not be placed at the surface of knitted structure to provide the necessary hygienic properties. The elastomeric yarns position inside the knitted structure can be provided by using the double fabric such rib 1x1 as a base, wherein the filling yarn is disposed between the face and reverse loops (Fig.1.). The special yarn feeder is required on the knitting machine used for the manufacture of such weft knitted fabric. This yarn feeder is located in front of the system. which is forming basic interlooping. The filling yarn is laid between the needle beds when the needle heads of both beds are disposed below the knock-over plane.

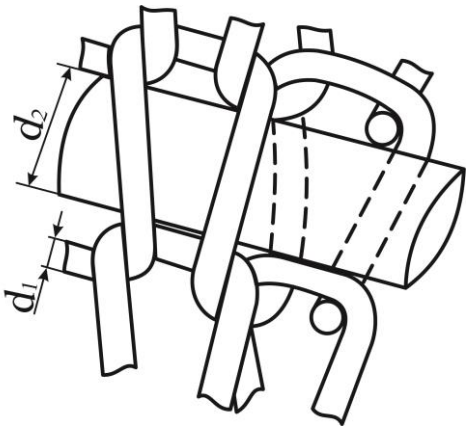


Figure 1. Rib 1+1 with weft inserted elastomeric yarn

At the same time, the quality of materials with incorporated elastomeric yarn is determined by the reliability of the elastane fixing in the structure that is increasing with an increase – in the contact areas between the elastomeric and conventional yarns. This can be achieved by increasing the density of knitting, when the loop height does not exceed the diameter of the filling yarn. However, there would be a problem with relaxation of the elastomeric thread in this structure, that would significantly affect the extensibility and elasticity of the fabric.

From the other point, the high fixing level of the elastomeric yarn can be achieved by the loops formation from this yarn [5]. This method is now widely used in the production of sports fabrics and linen from core-spun yarn with elastomeric core [6]. When using polyurethane without any wrapping the hygiene requirements to fabric are violated.

The simultaneous union of conditions of elasticity, hygiene and reliability of fixing of the elastomeric yarn is possible with miss knitting of elastomeric yarn through a certain number of needles in a certain courses. The elastomeric yarn is deployed as weft filling yarn in a certain number of missed wales and is connecting the formed loops.

2. Theoretical Consideration

It is possible to knit elastomeric yarn separately [7] or together [8] with conventional yarn. When loops are formed from both together elastomeric and conventional yarn. the elastomeric yarn is positioned inside the knitted structure. The loops from elastomeric yarn create an elastic frame between elements from conventional yarn. The loops' skeletons from conventional yarn are changing their position to coursewise direction. They are bending and are turning in a plane that is perpendicular to the fabric plane [9]. But when loops are formed from elastomeric and conventional yarn together, accordingly they are laid and draw-off simultaneously. In this case, the properties of knitted fabric are determined by conventional yarn: the elongation of the fabric is limited by junctures from conventional yarn that are most orientated in the stretching direction.

The elasticized fabric produced at separate knitting of elastomeric and conventional yarns are different. The elastomeric yarn is trying to regain its former size and to reduce its length after knitting and the termination of draw-off force. As a result, knitted fabric has got high elasticity, in this case the elastic properties depend on the pretension of the elastomeric yarn before knitting and on the degree of relaxation in the knitted structure [10].

This fabric is produced on double V-bed flat knitting machine equipped with a needle selection mechanism. The conventional yarn 1 is laid in the first knitting system and forms the loops of rib 1x1 (Fig. 2). The elastomeric yarn 2 is laid in the second knitting system with pre-elongation and forms the loops depending on the repeat. The elastomeric yarn can form loops by needles as only one needle bed (Fig. 2.a), or both needle beds (Fig. 2.b-d). One (Fig. 2.a-b) or two (Fig. 2.c-d) elastomeric yarn can be laid at one course, the elastomeric yarn can be laid in each course or according to a particular repeat. It`s possible to form the loops from elastomeric yarn on adjacent needles (Fig. 2.d), and with offset (Fig. 2.c) on different needle beds.

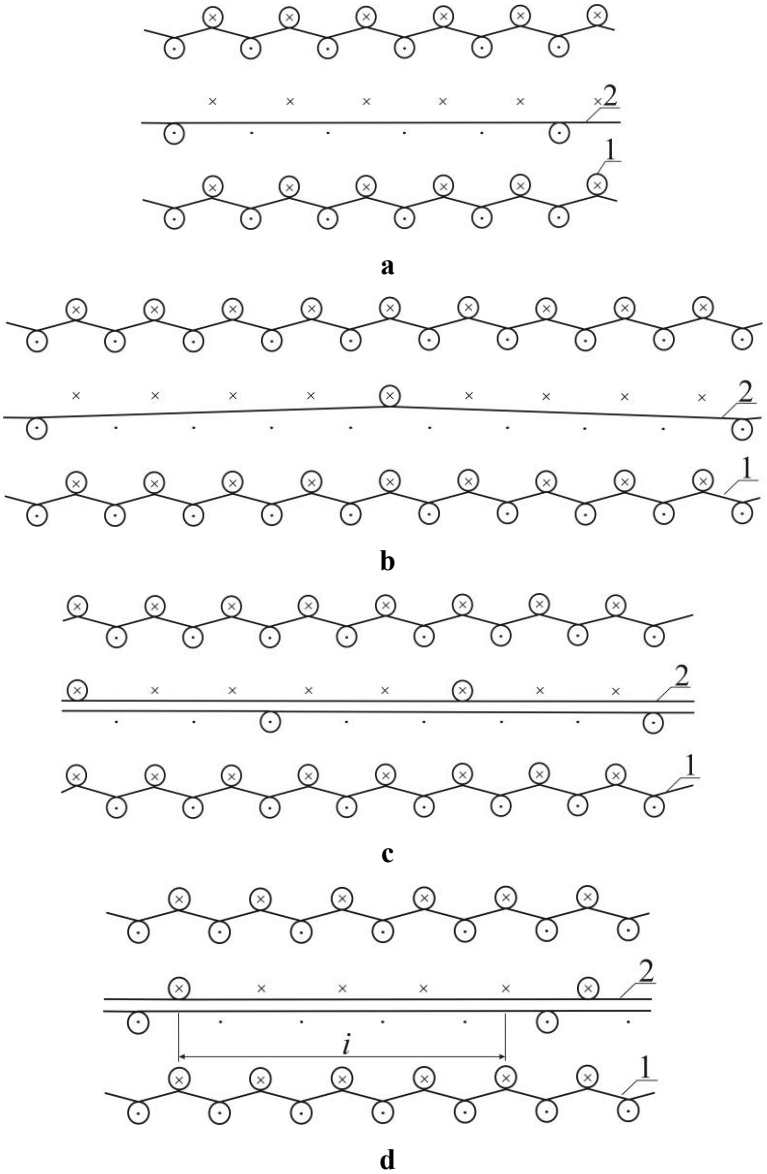


Figure 2. Variants of knit repeat

It is obvious that a preliminary elongation of the elastomeric yarn and the fabric density are the main factors that determine the structure parameters and mechanical properties of elasticized knitted fabrics [11]. However, it should be assumed that laid repeat [12] and miss knit repeat of elastomeric yarn will also affect the performance properties of knitted fabrics.

Thus, the main purpose of this study is to establish the influence of miss knit repeat of elastomeric yarn on the structure parameters and the stretch properties of elasticized knitted fabric.

3. Experimental Parameters

The weft knitted fabric that was formed by an alternation 2 courses of 1x1 rib from cotton yarn and 1 course of miss knit from core-spun yarn with elastane core has been chosen for this study. The loops from elastomeric yarn are formed by adjacent needles on different needle beds (Fig. 2.d). In order to verify the effect of miss knit repeat of the elastomeric yarn on the performance properties of the fabric, the number of missed wales between the loops from the elastomeric yarn has been varied from 2 to 10 with an interval of 2.

Experimental samples of knitted fabric have been produced on 10-gauge flat V-bed knitting machine. The weft knit fabrics were made from 31 tex * 2 cotton yarn as ground. The core-spun yarn with 90 tex polyurethane yarn covered by two end of 12.5 tex polyester yarn was used as elastomeric yarn. Elastomeric yarn was fed into the knitting zone with elongation of 145%. that made it possible to obtain high-quality fabric during loop formation.

The investigation of structure parameters and of strain characteristics of elasticized fabric was carried out according to standard methods after 72-hour relaxation in normal climatic conditions. The experimental results are presented in Table 1.

Table 1. Experimental Data

			Number of miss needles at the repeat, *i*				
			2	4	6	8	10
Length, mm	of loop	l_1	5.55	5.55	5.57	5.60	5.59
	of weft	l_2	0.84	0.83	0.81	0.80	0.79
Number per 100 mm	of courses	N_c	76	75	74	73	72
	of wales	N_w	86	88	92	96	98
Thickness, mm		T	2.20	2.16	2.10	2.06	2.01
Basic weight, g/m^2		m_s	658.18	664.34	669.98	674.48	677.78
Full stretch, %		ε	49.0	81.4	104.6	126.4	148.4
Parts of full stretch, %	elastic	ε_1	45.4	77.0	97.0	116.8	137.6
	plastic	ε_2	2.6	3.0	4.0	5.2	6.2
	residual	ε_3	1.0	1.4	3.6	4.4	4.6
Quota of part	elastic	$\Delta\varepsilon_1$	0.927	0.946	0.927	0.924	0.927
	plastic	$\Delta\varepsilon_2$	0.053	0.037	0.038	0.041	0.042
	residual	$\Delta\varepsilon_3$	0.020	0.017	0.034	0.035	0.031

4. Analysis

The single-factor mathematical models that describe the influence of missed knit repeat *(i)* of elastomeric yarn on the studied parameters were obtained as a result of mathematical calculation and are presented in Table 2. All dependencies are linear.

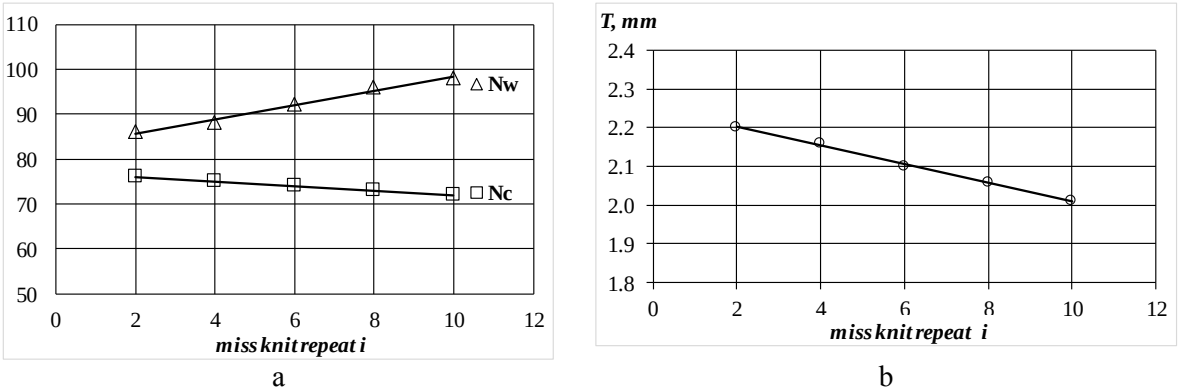
Table 2. The Mathematical models

№	Parameter	Equals
1	Length of elastomeric weft yarn, mm	$l_2 = -0.006\,i + 0.845$ $(R^2=0.81)$
2	Number of courses per 100 mm	$N_c = -0.4\,i + 76.5$ $(R^2=1)$
3	Number of wales per 100 mm	$N_w = 1.6\,i + 82.4$ $(R^2=0.98)$
4	Thickness, mm	$T = -0.02\,i + 2.25$ $(R^2=0.99)$
5	Basic weight, g/m^2	$m_s = 2.47\,i + 654.15$ $(R^2=0.98)$
6	Full stretch, %	$\varepsilon = 12.19\,i + 28.82$ $(R^2=0.99)$
7	Elastic stretch, %	$\varepsilon_1 = 11.21\,i + 27.50$ $(R^2=0.99)$
8	Plastic stretch, %	$\varepsilon_2 = 0.47\,i + 1.38$ $(R^2=0.97)$
9	Residual stretch, %	$\varepsilon_3 = 0.51\,i + 0.06$ $(R^2=0.90)$

4.1. Structural parameters

It is well known that yarn tension and force of fabric draw-off as well as draw-off level (knock-over depth) are the main factors that affect the loop length of weft knitted fabric. The loop length of rib 1x1 (l_1) is not affected by miss knit repeat of elastomeric yarn as all experimental samples are made on the same knitting machine at constant knitting parameters. At the same time, it was found that the average length of the elastomeric weft yarn (l_2) is reduced by increasing the number of missed wales. Such direct proportion is due to the difference in lengths of the loop and portion of weft yarn that connected two loops. So the length of weft yarn in fabric with 2 missed wales is two loop pitches and the length of weft yarn in fabric with 10 missed wales is ten loop pitches. Obviously, the average loop length of an elastomeric yarn in the fabric with 2 missed wales at the knitting repeat is the highest and the average loop length of an elastomeric yarn in the fabric with 10 missed wales at the knitting repeat is the smallest. It should be noted that the difference in the lengths of elastomeric yarn of the boundary options of missed knit repeat does not exceed 6 %.

Analysis of the results showed the greatest impact the miss knit repeat has on the number of wales (N_w) per 100 mm (Fig.3.a) and the thickness (T) of fabric (Fig.3.b). The number of wales is increased by 14 % and the thickness is reduced by 10 % with increasing the number of missed wales from 2 to 10.



a b

Figure 3. Stitch density (a) and thickness (b) of elasticized fabric

The thickness of the fabric with weft-inserted yarn is determined by the its diameter. Changes in the thickness of a knitted fabric can be explained by the different positions of elastomeric yarns in the knitted structure. According to the interlooping repeat (Fig. 2.d) two elastomeric yarns are laid in the course (Fig. 4). The loops from the ground yarn wrap them on both sides of fabric. This ground loops form curved configuration in the knitted structure. The two elastomeric yarns are positioning beside one another in the knitted structure with 2 missed wales at the knitting repeat (Fig. 4.a). The thickness of such structure equals two diameters of elastomeric yarns and two diameters of ground yarns. The

two elastomeric yarns are positioning one over another in the knitted structure with 10 missed wales at the knitting repeat (Fig. 4.b). The thickness of this structure equals one diameter of elastomeric yarns and two diameters of ground yarns. Moreover, in this structure the ground loops are less curved and more extended walewise (Fig. 4.b). This leads to an increasing of the loop height and correspondingly to reducing up to 5% the number (Nc) of courses per 100 mm (Fig.3.a).

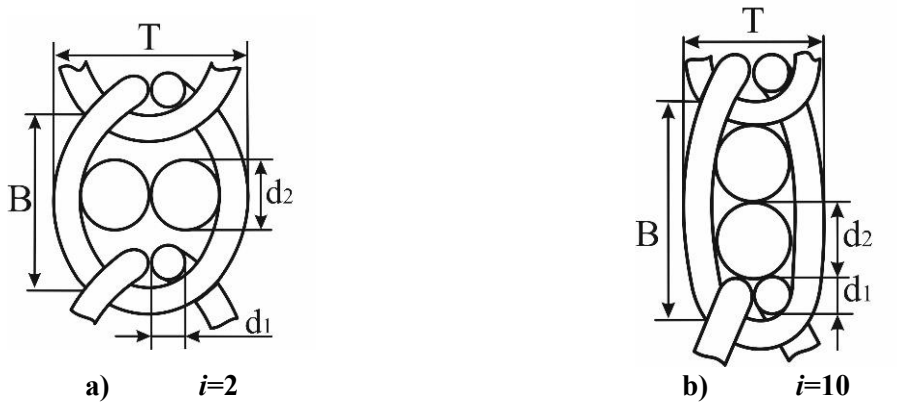


Figure 4. The positioning of filling yarns in knitted structure

The number of missed wales in knitting repeat does not affect the basis weight of elasticized knitted fabric. The difference in basis weight of the boundary options of miss knit repeat does not exceed 3%.

4.2. Mechanical properties

Extensibility and elasticity are the main characteristics of the elasticized fabric that determine their use for medical purpose. The experimental results show that full stretch of the knitted fabric with two missed wales at repeat is less than 75 % and does not satisfy the requirements. Full stretch of the knitted fabric increases with increase of number of missed wales and reaches 150 %. Different values of the full stretch are associated primarily with varying degrees of relaxation of elastomeric yarn in knitted structure of different variants.

As shown on the plots (Fig. 5) the elastic stretch is the largest part of the full stretch of elasticized knitted fabric. Quota of elastic part is more than 0.92 (Table 1), which is associated with the use of elastomeric yarn. Elastic stretch of the knitted fabric increases with increase of number of missed wales too as full stretch and depends on degrees of relaxation of elastomeric yarn in knitted structure.

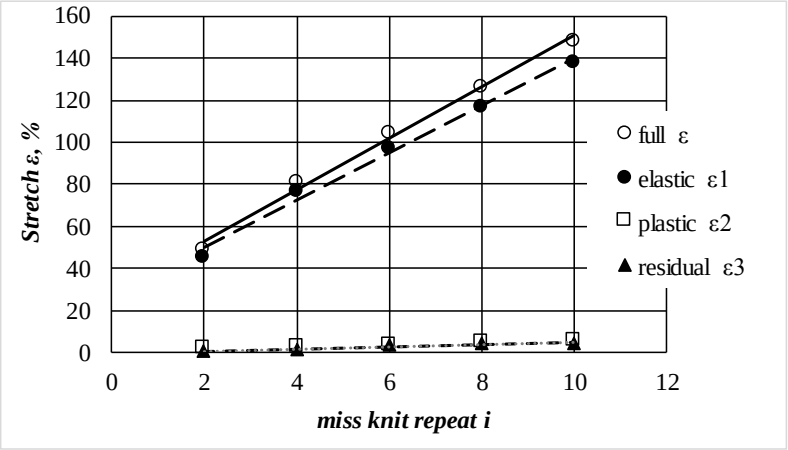


Figure 5. Full stretch and its parts

As for the plastic and residual components of the full stretch, they also increase with increase of number of missed wales at repeat (Fig. 5), but the maximum absolute value is respectively ε_2 = 6,2 % and ε_3 = 4,6 %. Thus, elasticized knitted fabric of different miss knit repeat can show acceptable dimensional stability.

5. Conclusions

The experimental data showed that the missed knit repeat affects the relaxation degree and position of an elastomeric yarn in the knitted structure, which in turn leads to changes in the structure parameters and elasticity of knitted fabrics.

The elasticized fabric with 4 ÷ 8 missed wales between the loops from the elastomeric yarn is recommended for using in abdominal binders in order to provide the necessary extensibility (80 ÷ 120 %) with low residual strain (2 ÷ 4%).

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