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THE INVESTIGATION OF THE LOOP LENGTH OF ELASTIC WARP KNITTED FABRIC

Olena Kyzymchuk, Svitlana Obukhevych, Liudmyla Melnyk

Kyiv National University of Technologies and Design KNUTD, Kyiv, Ukraine

ABSTRACT: *The loop length is the main parameter of the knitted structure, that affect the fabrics density and its basic weight as well as air permeability, strength, elasticity, and other properties. It affects also extensibility, width and length of product and, therefore, a whole appearance of the item. The study of the influence of knitting technological parameters on the loop length of elastic warp knitted fabric for the rehabilitation and preventional goods manufacture is the purpose of this research. The three-factor experiment has been planned and carried out during this study. The linear density of the weft filling-in yarn, the pre-elongation of an elastomeric thread and the tension of ground yarn were chosen as input factors. The regression equations that adequately describe the dependencies of the loop length on these technological parameters have been established.*

Keywords: *Loop length, warp knitted fabric, elastomeric thread, pillar stitch, weft filling-in yarn*

ISPITIVANJE DUŽINE PETLJE ELASTIČNE TKANINE PLETENE PO OSNOVI

APSTRAKT: *Dužina petlje je osnovni parametar pletene strukture, koja utiče na gustinu tkanine i njenu osnovnu težinu, kao i propusnost vazduha, čvrstoću, elastičnost i druge osobine. To utiče i na rastegljivost, širinu i dužinu proizvoda i, samim tim, na čitav izgled predmeta. Svrha ovog istraživanja je proučavanje uticaja tehnoloških parametara pletenja na dužinu petlje elastičnog osnovnog pletiva za proizvodnju sanacione i preventivne robe. Eksperiment sa tri faktora je planiran i sproveden tokom ove studije. Kao ulazni faktori izabrane su linearne gustine prediva za popunjavanje potke, pred-izduženje elastomernog konca i zatezanje prediva. Utvrđene su regresione jednačine koje adekvatno opisuju zavisnosti dužine petlje od ovih tehnoloških parametara.*

Ključne reči: *Dužina petlje, tkanina pletena po osnovi, elastomerni konac, stubni bod, predivo za popunjavanje potke*

1. INTRODUCTION

The modern world is characterized by the rapid development of science and technology, aimed at the development of new spheres of human activity, which often leads to a change in a personal lifestyle and his health deterioration. The use of textile materials in the medical field has a deep history, however, today it is one of the most attractive areas of the textile industry [1,2]. A special niche is a compressive product which creates pressure on the human body. According to a number of studies [3-6], they are indispensable for the prevention and even conservative treatment of certain human diseases. These include elastic bandages, abdominal binders, armbands for joints fixation, compression clothing, and hosiery, etc. Therefore, the work aimed at the development of materials used for the prevention of various diseases is relevant today.

Knitting is a complex mechanical process, the object of which is a thread; the products of this process are loops, which knitwear is formed. The structure of knitting fabrics varies from very heavy to very light ones. The loop shape that formed during the knitting depends on qualitative and quantitative factors, the most important of which is the length of the thread in the loop [7]. The loop length is the main parameter of knitwear, which affects the geometrical and physicomechanical properties, product appearance, and depends on the technological parameters of knitting.

Since medical textiles are directly related to human health, the requirements for such products have to strict compliance during production. The materials used for the manufacture the products for therapeutic and prophylactic purposes should strictly comply with hygienic and physicomechanical properties. Namely, textile materials should ensure uniform pressure distribution, be tensile without restricting the usual level of human mobility, maintain linear dimensions during using, even with multiple washes, while maintaining functional properties. In this regard, there are certain restrictions on choosing raw materials, interlooping, technological parameters of production.

Mostly, the basis of such products is a knitted fabric containing an elastomeric thread. A significant expansion of the product range for treatment-and-prophylactic purposes is primarily due to the use of elastomeric filaments with more than 95% elongation and the capability to recover their original dimensions after the load removal [8]. The fabric containing an elastomeric thread belongs to as highly stretchable, which residual deformation does not exceed 5%, and this property is preserved during using. The stretchability, elasticity, compressive capacity, when used in the stretched state, are their features also.

2. THEORY

The today's market of elastomeric yarns, which are used for the medical textile production, is represented by monofilaments and reinforced yarns, which are obtained by twisting or pneumatic connection lengthwise an elastomeric core with threads, as well as by intertwining with fibers of different origin [9]. Given the fact that the additional processing of elastomeric yarns leads to a change in their original properties, it is advisable to use monofilaments. However, difficulties arise due to their low knitting ability, namely the significant friction forces in the yarn feed and loop-forming systems. Therefore, the choice of interlooping and technological parameters of knitting is an important issue.

The type of interlooping, its properties are determined by the sequence of the arrangement the structure elements: loops or threads of different raw materials. That is, the direction of the elastomeric yarn laying in the fabric structure and the method of its fastening, as well as the position of the elastomeric yarn (inside or on the surface of the knit), will determine the fabric properties. Contact of an elastomeric yarn with the loop-forming organs of the machine is excluded with its introduction into the knitted structure as inlay-in yarn. The knitted fabric has got its minimum percentage, increased elongation in one direction only while revealing the largest proportion of rapidly reversible deformation.

The reliability of elastomeric yarns fixing in the knitted structure, fabric elasticity and elongation are important factors determining the quality of the fabric. The reliability of elastomer yarns fixing in the structure is due to the presence of contact points of these yarn with the ground threads. The required elasticity and stretchability of knitted fabrics are due to the value of elastomeric yarns` pre-stretching before knitting and their capability to restore the original dimensions in the knitted structure after removing the stretching force.

Considering the need to ensure special requirements for textile for treatment-and-prophylactic products, the four guide bars are used for warp knitted fabric formation. A closed pillar stitch is used as a ground, the ground guide bar is full. The elastomeric threads are filling longwise with pre-elongation to ensure the elastic properties of the fabric. The threading of guide bar is full too. The pillar wales are connected with transverse wefts, which are laid by two yarn feeders on the entire fabric width on both sides of the elastomeric threads.

The use transverse wefts threads of linear density, which exceeds the linear density of the ground threads and the elastomeric yarn, makes it possible to create a dense structure that prevents the elastomeric yarn from coming out on the fabric surface. Longitudinal and transverse threads are located between the overlap and the underlap of the pillar stitch, which tightly wraps around them and securely holds them in the structure. This knitted fabric has high dimensional stability and provides comfort since the elastomeric yarns are located inside the structure and do not contact with the human body.

The loops configurations in the knitted structure of the same interlooping from the same linear density threads of the same composition are different and depend on the loop length. Loops size, which obtained during the knitting, depends on the technological parameters of the knitting process [10]. Accordingly, the degree of elastomeric yarns recovery and the reliability of their fixation in the knitted structure will be determined by the size and shape of the ground loops.

3. EXPERIMENTAL SAMPLES

In order to research the influence of technological parameters on the properties of fabric three factors experiment has been planned and carried out during this study. Next three technological parameters have been chosen: x_1 - the linear density of weft inserted yarn; x_2 - the tension of the ground yarn; x_3 – the pre-elongation of the elastomeric thread. The linear density of weft inserted yarn has been changed by yarn ends (k) that inlaying at each side of fabric: 2, 3 or 4. The tension of ground yarn has been changed by the additional load (q) on the yarn: 2, 6 or 10 g. The pre-elongation of elastomeric thread (ε) has been fixed at levels 210, 240 and 270 %.

All samples were made on a 15 gauge TCH Crochet Knitting machine. The polyester yarn 16.7 tex was used as ground and the polyester yarn 33.4 tex was used as weft. The polyurethane with 0.8 mm diameter has been used as elastomeric thread.

3. RESULT AND DISCUSSION

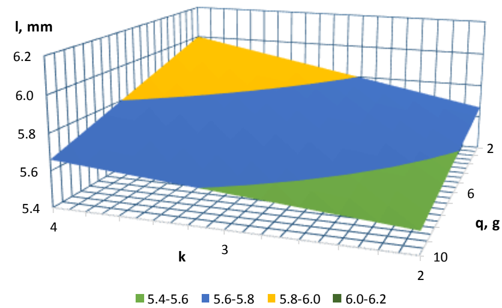
Mathematical dependencies of the loop length of the pillar stitch on technological factors have been obtained by mathematical processing of an experimental data (Table 1).

Table 1: Regression equations

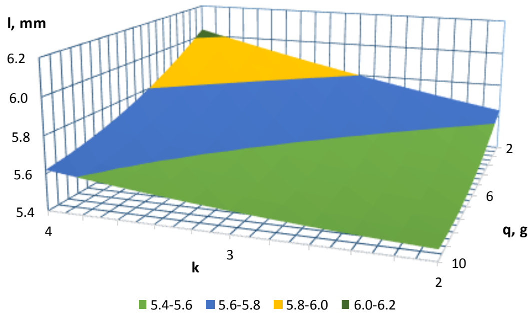
Fixed factors level	loop's length of pillar stitch, mm
ε = 210 %	$l_c = 5{,}31 + 0{,}20\ k + 0{,}01\ q - 0{,}01\ k\ q$
ε = 240 %	$l_c = 5{,}52 + 0{,}08\ k - 0{,}05\ q - 0{,}014\ k\ q + 0.02\ k^2 + 0.004\ q^2$
ε = 270%	$l_c = 5{,}11 + 0{,}23\ k + 0{,}03\ q - 0{,}02\ k\ q$
q = 2 g	$l_c = 5{,}51 + 0{,}185\ k - 0{,}001\varepsilon$
q = 6 g	$l_c = 5{,}23 + 0{,}14\ k$
q = 10 g	$l_c = 5{,}35 + 0{,}06\ k$
k = 2	$l_c = 5{,}74 - 0{,}06\ q + 0{,}004\ q^2$
k = 3	$l_c = 5{,}81 - 0{,}02\ q$
k = 4	$l_c = 6{,}09 - 0{,}05\ q$

The obtained data show, that the additional load on the ground yarn is the most influenced factor on the loop length of the pillar stitch. Since it increases the tension of the ground yarn, the value of the output factor decreases and within the scope of the experiment it corresponds to 10%. The increase in the linear density of the transverse weft yarn leads to an increase in the loop length of the ground interlooping, as evidenced by the positive coefficient in front of the factor k (x_1). Since the transverse weft thread is covered by the loop overlap and the loop underlap and the pillar stitch is drawn, its length must be equal to or greater than the diameter of the transverse weft thread. The change of the output factor occurs within 7%. The change of the pre-elongation of the elastomeric yarn does not influence the loop length of the pillar stitch, as indicated by the absence of this factor in the regression equations.

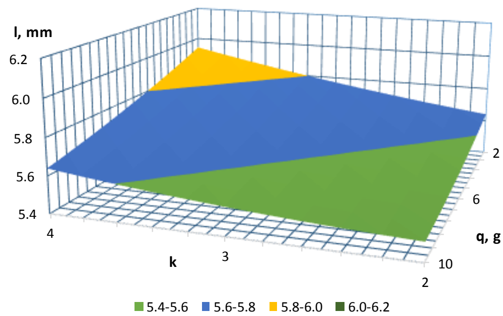
In this case, graphic interpretation of regression equations of loop length on x_1 and x_2 factors are shown on Fig.1 on three fixed levels of the parameters x_3. The obtained experimental data show that at the maximum value of the additional load on the ground yarn, the loop length of the pillar stitch varies within 3% when comparing all fabric options, despite the fact that the linear density of the transverse weft thread changes within 25%. It can be assumed that with the maximum value of x_1 and x_2 factors, the weft yarns are located in the perpendicular plane to the fabric, changing the configuration of the ground loop and its contact area with the elastomeric yarns. It is necessary to develop a geometric model of such knitted structure to determine the relative position of the elements of the studied structure, as well as the ability to predict parameters and properties of the fabric at the design stage.



a. ε = 210 %



b. ε = 240 %



c. ε = 270%

Figure 1: Dependences of loop length on weft yarn ends (k) and the additional load (q) on the ground yarn at fixed pre-elongation of elastomeric thread (ε)

3. CONCLUSION

Elastic knitted fabrics are an indispensable basis for the production of therapeutic and prophylactic products. At the same time, there is a number of requirements for these materials. The requirements fulfillment is possible by the technological parameters of knitting, which provide the necessary parameters of the knitted structure and its properties. Since the loop length is the main structural parameter of knitted fabric, which determines its properties, its change has been studied in this work. It is determined that the change of the pre-elongation of the elastomeric yarn before knitting zone does not influence the loop length of the ground interlooping. The additional load on the ground yarn is the most significant factor that affects the loop length of the pillar stitch. The value of the output factor decreases by 10% within increase the additional load from 2 to 10 g. An increase of the linear density of the transverse weft yarn leads to an increase of the loop length within 7%.

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