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DEVELOPMENT OF FUNCTIONAL KNITTED MATERIALS FOR THE MANUFACTURE OF FUNCTIONAL COMPRESSION COVERS FOR STUMP

Purpose: *to study the effect of the speed of elastomeric yarn feeding into the knitting zone, its location in the pattern structure and course density in the process of producing tubular knitted material on its structural parameters and deformation characteristics under the influence of operational loads (deformation and deformation relaxation).*

Key words: *medical textiles, knitted material, deformation of textile material, deformation relaxation of textile material, cover for the stump, elastomeric yarn.*

Introduction. In case of amputation of a limb, compression covers are used to prevent post-traumatic edema, improve blood circulation in the stump and avoid edema formation after removal of the prosthesis. This is an important tool for prosthetics in the postoperative period, as it provides uniform pressure that decreases from the distal to the proximal direction. Compared to elastic bandages, compression covers have several advantages: they are easy to use, well-fixed on the amputated limb, quickly eliminate swelling, comfortable to wear, have sufficient air and vapor permeability, and absorb moisture [1, 2].

The covers are tubular products with a welt and a bowl. The range of stump covers is determined by the level of amputation and physical activity of the user. Taking into account the level of amputation, there are compression stump covers for the first and second compression class (two types of length: for amputation above the ankle and below the knee), as well as hip stump covers also of two compression classes (with two lengths: for amputation above the knee and below the groin). It is important to note that the compression stump cover for below-the-groin amputations has an additional system of attachment to the patient's belt [1,2]. The development of functional tubular knitted materials for the manufacture of stump covers

involves a preliminary stage of studying the influence of technological parameters and its consumer characteristics.

Methodology. In accordance with the existing standardized test methods [3-5], the following structure parameters of the developed knitted material samples were determined: yarn length in the loop of the ground, horizontal (course) and vertical (wale) density, thickness, and surface density. In addition, the length of the elastomeric yarn segment per loop of the pattern, the width of the knitted material tube in the conditionally equilibrium and stretched (stressed) states were also determined. In the process of choosing the method of testing the deformation characteristics, a comparative analysis of the methods of determining the stretching ability of elastic knitted material is taken into account [6].

Research results. With the purpose to study the nature of the effect of knitting density, input tension of the elastomeric (rubber) yarn and the nature of its use in the knitted structure, prototypes of tubular shape were produced on a gauge 13 circular-hosiery knitting machine with a cylinder diameter of 3 3/4 inches (168 working needles). The vertical (course) knitting density was adjusted at three levels (90, 100 and 110 courses per 100 mm of the knit), as well as 4 levels the speed of the elastomeric yarn feed into the knitting zone (speed of the wheel feeding the elastomeric yarn 50, 70, 90, 110 min^{-1}) were chosen. The prototypes of tubular knitted materials were produced with two different laying repeats of 9.9 tex linear density elastomeric (rubber) yarn with double braiding of 4.4 tex polyamide textured yarn: in the shape of a tuck and float with 1×1 and 1×3 fleece pattern repeats. A smooth plain pattern was chosen to form the ground of the knit, where cotton yarn with a linear density of 20 tex was used as a cover yarn and a textured polyamide yarn of 4.4 tex with an elastane core of 2.2 tex was used as a ground yarn. Characteristics of the tested knitted samples are given in Table 1 [2].

Table 1– **Characteristics of the tested knitted samples are given**

Sample code	Speed of wheel supplying elastomeric inlay-yarn v, min^{-1}	Wale density P_w, cm^{-1}	Course density P_c, cm^{-1}	Area density, M, g/m^2	Loop length of plating cotton yarn, mm	Loop length of textured-elastomeric PA-EL ground yarn, mm	Average length of textured-elastomeric PA-EL inlay-yarn per one wale, mm
Pattern repeat 1×3							
3×1/11/50	50	11	11	481.2	6.1	5.5	0.9
3×1/11/70	70	10		461.6			1.0
3×1/11/90	90	9.5		450.4			1.1
3×1/11/110	110	9		450.0			1.2
3×1/10/50	50	11	10	483.6	6.7	6.1	1.0
3×1/10/70	70	10		480.8			1.1
3×1/10/90	90	9.5		462.0			1.2
3×1/10/110	110	9		456.8			1.3
3×1/9/50	50	11	9	482.4	7.3	6.7	0.9
3×1/9/70	70	10		443.6			1.0
3×1/9/90	90	9.5		428.4			1.1
3×1/9/110	110	9		417.6			1.2
Pattern repeat 1×1							
1×1/11/50	50	11	11	410.8	5.6	5.2	0.9

1×1/11/70	70	10		410.2			1.0
1×1/11/90	90	9		409.2			1.0
1×1/11/110	110	8.5		402.4			1.1
1×1/10/50	50	11	10	414.4	6.2	5.8	0.9
1×1/10/70	70	10		404.0			1.0
1×1/10/90	90	9		390.8			1.1
1×1/10/110	110	8.5		397.6			1.2
1×1/9/50	50	11	9	423.2	6.8	6.4	0.8
1×1/9/70	70	10		416.0			0.9
1×1/9/90	90	9		403.2			1.0
1×1/9/110	110	8.5		400.8			1.1

Deformation characteristics of the developed samples of knitted materials were studied in the longitudinal (wale) and transversal (course) direction on a 'Stand' type relaxometer at a low level of operating load equal to 6N. When choosing this load to determine the components of the strain (rapid, slow, and residual), we took into account the fact that the products (stump covers) made of the tested knitted material samples have a tubular shape obtained directly in the process of knitting with the use of a small-diameter circular knitting equipment and will not be subjected to greater force loads during operation when putting on the stump cover.

Conclusion. The results of experimental studies indicated that the length of the yarn in the loop is influenced by the set parameter of the vertical knitting density and the elastomeric yarn laying report. All other studied parameters of the loop structure and linear measurements of tubular knitted semi-finished products were sensitive to changes in the speed of elastomeric yarn feeding into the knitting zone, vertical knitting density, and the repeat of elastomeric (rubber) yarn' laying in the main structure of the knitted material. The correlation dependencies established during the research allow the design of knitted materials and tubular products for covers with specified parameters of the loop structure.

In all the developed samples of knitted materials, the proportion of residual deformation does not exceed 4%, and it increases with decrease of the knitting density and increase of the speed of elastomeric yarn feeding

into the knitting zone. At the same time, the value of the total deformation under the operating load is affected by the pattern of the elastomeric yarn laying. Thus, in case of the laying report 1×3, a greater value of the total deformation, both in width and length, was observed. This is due to the formation of a relief surface of the knitted material (longitudinal rollers in places where the elastomeric yarn is located in the form of a float along 3 looped columns) in the case of the 1×3 elastomeric yarn laying repeat.

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